The SCIENTIFIC MONTHLY

AUGUST 1946

Contents

Science and Incentives in Russia . . . . *Irving Langmuir* 85
The Responsibilities of Health-Physics . . . . . . *Karl Z. Morgan* 93
What Sound Hath Wrought—I . . . . *Nathan Levinson* 101
Does the Sting Ray Strike and Poison Fishes? . . . . *E. W. Gudger* 110
The EPC Banishes Science . . . . *Franklin Bobbitt* 117
To the New Physics (Verse) . . . . *A. E. Johnson* 124
Science and National Policy . . . . *Karl T. Compton* 125
On the Mathematics of Committees, Boards, and Panels . *Bruce S. Old* 129
Freedom is Fitness . . . . *Archie J. Bahm* 135
Freedom for What? (Verse) . . . . *John G. Sinclair* 136
Science as the Common Ground for Relations between Nations.
M. Pijoan and F. Trowbridge vom Baur 137
Book Reviews 141
Science on the March 149
Comments and Criticisms 157
Meet the Authors iii

Boston Meeting, A.A.A.S., December 26–31, 1946

PUBLISHED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A. A. A. S. Building, Washington 5, D. C.

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SCIENCE AND INCENTIVES IN RUSSIA

By IRVING LANGMUIR

ON MAY 19, 1945, less than two weeks after the end of the war in Europe, I received from the Embassy of the U.S.S.R. in Washington a short letter inviting me "to participate in the festivities to be held in Moscow and Leningrad from June 15 to June 28 in celebration of the 220th anniversary of the Academy of Sciences of the U.S.S.R." In a postscript it was stated that "travel expenses and expenses of a sojourn in the U.S.S.R. will be paid by the Academy of Sciences of the U.S.S.R." No other information, giving more particulars as to the nature of the meetings that were planned, was received from the Embassy.

I called up the State Department regarding the possibility of getting a passport and priority for transportation. They had no official knowledge of these invitations, but a few others who had been invited had telephoned as I had. It was doubtful that more than two delegates from America could be sent, but I was asked to call again the next day for more information. The following day I was told that passports and priorities would be issued for all those invited. The time was short, and it would be necessary to go by airplane, but because of the heavy Army traffic it was not possible to decide upon the route until two days before departure. The possible routes were via England or by way of Africa and Teheran, via Newfoundland, Bermuda, or South America. It was essential to make application for passport and transportation immediately, so forms were mailed at once from Washington. When they arrived I found difficulty in filling them out, for the passport application required me to state the date of departure, the route, and all stopping places; the application for transportation required me to give the number of my passport.

I filled out everything I could and wrote a letter saying that the State Department had informed me that the particular route could not be decided until a few days before departure. I needed to be in Moscow on June 14 and suggested that the State Department fill in the blank spaces. (When I returned from my trip to Russia early in July, I found that several days after my arrival in Moscow the State Department had written me that my passport and application for transportation had been rejected because the application forms had not been completely filled out.)

I accepted the Soviet invitation by telephone and letter and was informed that transportation would have to be arranged for by the United States government. On the evening of Monday, June 4, I suddenly received a telegram indicating that I must be in New York by

Tuesday noon to get proper visas for my passport, which was to be brought by special messenger from Washington. A Soviet plane would start from San Francisco, picking up delegates on the way, and would leave New York early Wednesday morning, taking the whole delegation to Moscow via Alaska and Siberia. The baggage was "limited to 25 to 30 pounds." We found later that this should have been 30 kilograms, or about 66 pounds.

Two members of the party arrived in New York on the Soviet plane Wednesday afternoon, but because of minor difficulties this plane was not ready to leave until Thursday evening. In the meantime, we found that the Soviets would not be allowed to operate passenger planes in the United States, and the only plane available was a cargo plane with insufficient seats for the whole party. It was, therefore, finally arranged by the State Department and President Truman that the party would be taken by the Air Transport Command in a C-54 plane to Teheran via Newfoundland, the Azores, Casablanca, and Cairo. A Russian plane would meet us at Teheran, and we would return from Moscow in a Russian plane to Fairbanks and thence to the United States by an Army plane. The final party as it left America consisted of James W. Alexander, Merrill Bernard, Detlev W. Bronk, James W. Church, Henry Field, Jacob Heiman, Charles E. Kellogg, I. M. Kolthoff, Irving Langmuir, Duncan MacInnes, James W. McBain, A. P. Nadai, A. U. Pope, Harlow Shapley, Edwin S. Smith, and M. S. Vallarta. The party was joined in Moscow by T. von Karman. There were thus 5 chemists, 2 archeologists, 2 meteorologists, and 1 each from the fields of mathematics, biology, medicine, astronomy, and mechanical engineering. No physicists were among the delegates, although 12 had been invited.

It is a serious reflection on the state of American public opinion and understanding of Russia that most of our friends felt we were undertaking a hazardous expedition. Many of them warned us that 16 Poles had been "invited" to Russia and that they did not come back; they wished us better luck.

We finally left New York early on the morning of June 10 and arrived in Russia at Baku on the Caspian Sea at 8 o'clock on the morning of June 14, after having spent 24 hours in Cairo. At Baku we were met by a group of local public officials and members of the newly formed Academy of Sciences of Azerbaijan. We were then at 8:30 A.M. taken to a banquet with perhaps 25 different articles of food, including two kinds of caviar, smoked sturgeon, cold and hot meats and fish, with several kinds of wine. Although during our short stay in Cairo some members of our party had acquired dysentery (which was quickly cured by sulfa drugs), we were assured that in Russia it was always safe to drink water. I saw a large carafe on the table in front of me and filled a glass, only to discover quite suddenly that it was vodka, which contains 50 percent alcohol. We always found that vodka and water were in identical carafes.

After a perfunctory baggage examination we left Baku by plane and in perfect weather flew via Stalingrad to Moscow, a distance of about 1,100 miles. Beyond Stalingrad we flew for 500 miles over an unbroken area of collective farms visible for a hundred miles on each side of our route. All the land was under intensive cultivation. It included about 10 percent forest. At frequent intervals we passed over "inhabited places," like those we heard so much about during the war. They were usually villages of perhaps 50 well-separated houses, arranged on both sides of a street or road about 200 feet wide. Each house had its

own vegetable garden of about an acre. Most of these towns had small artificial lakes or ponds. Each village was surrounded by the collective farm of many hundred acres cultivated by use of tractors. We were so much interested in these farms as seen from the air that we arranged to visit one of them during our stay in Moscow. At the same time we were also shown a State Farm.

Arriving at Moscow about 6 P.M., we were met by a large delegation of prominent Russian scientists, including P. Kapitza, A. Frumkin, and J. Frenkel, all of whom I had previously met. We were then taken to the National Hotel. One by one we gave up our passports to the hotel clerk and were assigned rooms on the second and third floors. I happened to be the last one to check in. After I had given up my passport I was motioned to a chair near the desk and there I sat for well over half an hour. No one around me spoke English. Gradually I became aware that the steady stream of people who stopped at the desk were talking about me. Although I had plenty of time to think about the remarks of my friends regarding the 16 Poles, I was more amused than worried.

A man who spoke a little English finally came to me and explained, "You are not staying here."

I replied, "But I would rather stay here with the rest of the party."

"None of them is going to stay here," he answered. So one by one the men who had unpacked their bags and made themselves at home in their comfortable quarters were notified by means of sign language that they should repack their bags and go down to the lobby.

The mystified delegates were taken with their belongings in a large bus across the street to the Moskva Hotel, which had been used exclusively by Russians. There we had excellent adjacent rooms with baths, all on the eighth floor. There was a convenient meeting place having a large table and comfortable chairs, with desks for the women who were to act as translators, provide for our transportation, etc. It was, in fact, a much better arrangement, but we were surprised that it had not been thought of until we were already installed in the National Hotel.

This and many other similar situations made us realize how few parties such as ours had traveled in Russia. Edgar Snow has recently written from Moscow that there are only 260 Americans in the whole of the Soviet Union. Everywhere we met the utmost kindness, but all those who looked after us were having a new experience, as novel for them as it was for us.

The next morning, after brief consultation with some of the others, I asked one of our interpreters how we could get some Russian money in exchange for our traveler's checks. She looked at me in astonishment and said, "What do you want Russian money for?" I said that I might want to buy a newspaper or ride in a subway or take a taxi. She assured me that all such things had been thought of and would be taken care of. There were no taxis, and we would have automobiles at our disposal to take us wherever we wanted to go; for instance, we would certainly be taken to see all the important stations of the subway as the subway is one of the sights of Moscow; as for newspapers, we would receive the *Moscow News* in English before breakfast. I then suggested that I might like to buy a present to take home to my wife. She remarked, "Oh, I don't think you will want to do that"—and, in fact, I didn't. I then wondered whether there was a real desire that we shouldn't have Russian money. When I suggested this, my interpreter was horrified at such an idea and said, "No, of course not." She

clearly was merely surprised at the thought that we should want money when all our hotel bills and other necessary expenses were being taken care of. This was one of many experiences that demonstrated to me the relatively small part that money plays in the lives of the Russians.

Still wishing to obtain Russian money, however, we found it involved many difficulties that had not been foreseen. There was only one bank in Moscow that could deal in foreign exchange, and there, to get money in return for traveler's checks, it would certainly be necessary for us to have our passports and to have somebody who could identify us. The trouble was that the passports had been given up at the hotel and would not be returned for five days. I finally acted as agent for the whole party, arranged to get my passport from the safe where it had been kept, and with a young man from Intourist went to the bank and got $250.00 in rubles for the whole party. During the rest of our stay we all tried to discover ways in which we could spend the money. We had been given rubles at the official rate of exchange of 5 rubles to the dollar. (The American Embassy and its staff gets 12 rubles to the dollar.) A few days later, during an intermission at the opera, we went to a restaurant where refreshments were being served. We found that one piece of French pastry cost $8.00, and a cup of tea or glass of beer, $3.50. Chocolate bars sold at $85.00 a pound; a plate of ice cream, $6.00. Yet the place was crowded, and people were waiting in line to buy ice cream.

On the streets healthy looking peasant children of six dressed in heavy, padded winter clothing, presumably because they did not have any summer clothing, were buying very small amounts of ice cream for $2.00.

My bewilderment at this kind of economic system led me to ask many questions. I found that the people's purchasing power is determined by a farreaching rationing system which applies to food, clothing, cigarettes, housing, railroad transportation, and even opera tickets. Rationed goods are sold only at certain stores at low fixed prices which are about the same as those before the war. At the rate of 5 rubles to the dollar these prices are not greatly different from those in the United States. The balance of supply and demand is not regulated by prices but by the number of ration points that are issued.

There are also a large number of other government-operated stores called commercial stores, which in Moscow all carry the name *Gastronom*. In these stores no ration points are needed, but the prices are fantastically high, ranging from 10 to 100 times as much as those at stores selling rationed goods. Every worker or employee receives much more money than is necessary to buy his allotted amount of rationed goods. The surplus can be used only for goods at extremely high prices. It is no wonder, then, that money is regarded as not having great value.

In the commercial stores the balance of supply and demand is adjusted by flexible prices rather than by wages. The high prices at these stores reflect wartime scarcities. Already, before June 1945, there had been two cuts, averaging about 25 percent each, in the prices, and I understand that since then there have been further substantial reductions. It is interesting that books and other goods which are considered to be of cultural value sell at prices about like those in England and America.

There are also great numbers of free markets where anyone can buy and sell or exchange articles without government restrictions on prices. Competition naturally holds these prices somewhat lower

than those at the commercial stores. There were 49 such markets in Moscow alone. Produce raised by the farmers of the collective farms on their private one-acre lots is sold at high prices in these markets. At the stations where we stopped on our train trip from Moscow to Leningrad we found that farmers were selling milk at $4.00 a glass, with plenty of demand for their product. It is not surprising, therefore, that peasant children can afford to pay $2.00 for ice cream.

The rationing system serves as a basis for the remarkable system of incentives that dominates Russian life. This system was started in 1931 when the Soviet government adopted the policy that men should "serve according to their abilities and be paid according to their services." Piecework rates are universal throughout industry, but when definite quotas and superquotas are exceeded, the piecework rate often increases as much as two- or threefold for all output exceeding the quotas.

The Russians justify this by explaining the great reductions in "overhead" that are possible when the output of a man increases. With the increased pay go corresponding increases in the allotment of rationed goods.

The spread in the rates of pay in Russia is even greater than in the United States. For example, if a man works up into a good position, he may receive as much as five times more food ration points. Just imagine the protests that would have arisen in America during the war if a college professor or the president of a company had received more red ration points than a factory worker. In Russia, however, since they have adopted a powerful incentive system and the pay for services rendered consists primarily of ration points, it is logical that the allotment of food and other rationed goods should vary in quantity with the work done or the position held. In many cases the food allotted to an individual is far more than can be consumed by him. That means he can entertain his friends or can even sell the surplus on the free market. For example, people who do not smoke may buy their allotment of cigarettes at low prices and then sell them in the streets for one ruble (20 cents) each.

There are many other provisions for increasing incentives. Special prizes are offered those factory workers who have the greatest output. The women who acted as translators for us during our stay in Moscow received not only their usual salary but got as a bonus coupons which entitled them to buy two pairs of silk stockings at low prices.

For scientists there is another kind of incentive. Just before the anniversary meeting of the Academy of Sciences 13 Russian scientists were awarded the highest of all honors, "Hero of Socialist Labor"; 196 received the Order of Lenin, which only a few months ago was awarded to Molotov. A total of 1,400 awards was made. An article appearing in the *Moscow News* in June 1945, entitled "Science Serves the People," contained the statements:

> Never before has the scientist been accorded such attention by the state and such esteem by society as in the Soviet Union. . . . The state provides the maximum amenities for life and facilities for work to the scientist and assures a comfortable life to his family after his death.

It is continually being pointed out by the Russians that their system of incentives is rapidly increasing the efficiency of production and is thus one of the main factors that will help to make Russia great and will make possible a high standard of living. When I expressed surprise that so much emphasis should be placed on incentives the reply was usually, "But I thought that it was a particular characteristic of your capi-

talist system in America that great rewards were given to those who became leaders or acquired important positions in industry or business." I had to explain that in America that was originally one of the effects of the capitalist system, but that in recent years our government had regulated and controlled all incentive payments by taxes and by special laws so as to stifle incentive to a large degree.

THE meetings of the Academy were, as was indicated by the wording of the invitation, "festivities" commemorating the anniversary. Detailed scientific papers were not presented. The plenary meetings, which were held in large opera houses with about 3,000 people present, were devoted to a few general papers on the history of science in Russia and in other countries and on selected subjects of wide general interest.

Most of the meetings included entertainments such as symphony orchestras, ballets, or operas. All these performances were of extraordinarily high quality. They demonstrated very clearly the great importance that the Russian government and people attach to cultural subjects. Later, as we came back across Siberia, we stopped at Novosibirsk, a town which had grown from 80,000 to 900,000 during the war. During this growth, even at a time when the housing facilities were very inadequate, the government built an opera house seating about 3,000 people and arranged for operas, concerts, and other entertainment of the same quality as at Moscow.

The anniversary celebrations included three banquets for 1,100 guests, with all the lavishness that was characteristic of prewar Russia. The last of these banquets was held at the Kremlin in Moscow with Stalin in attendance and Molotov as toastmaster. Before leaving America I had been repeatedly warned about the excessive drinking at such banquets. In Moscow, only a few hours before the banquet at the Kremlin, I was told by a man in the United States Embassy that this banquet would be "the real thing," and that for the toasts to Stalin of which there might be thirty, it was essential to drink vodka only; a full glass must be emptied for each; to do otherwise was considered an insult. Actually, I found less drinking than is usual in America. At the three banquets I saw only one man who reached the slightly-incoherent stage. About half the Russians responded to a toast to Stalin merely by clapping; the others, after the clapping, lifted their glasses and took a sip or two of wine, vodka, or orangeade. So far as I could judge from observations of Russian scientists, the drinking habits and capacities of the Russians are greatly exaggerated.

The Academy of Sciences has 142 regular members and 200 corresponding members. Membership is determined by secret ballot by members only. Corresponding members have "a voice but no vote." All members receive salaries from the government. The Academy has 8 sections, which include not only the natural sciences, biology and medicine, but also social sciences such as economics and law, history and philosophy, language and literature.

Within the Academy are 78 Institutes employing 15,000 men and women. The planning of the work of the Institutes is done by the members of the Academy, and they are responsible for its success. In Russia there are about 790 universities, with over 600,000 students, but these are not connected in any direct way with the Academy of Sciences.

More than 100 foreign scientists attended the anniversary meetings as guests. Most of our time during the 18 days in Moscow and Leningrad was spent in informal conferences in any of the

Institutes that we wished to visit. I naturally chose those in the fields of chemistry and physics. The Russian scientists talked freely about their work and showed me all through their laboratories, but they never sought information about work that we had been doing during the war nor about industrial developments in America. I was nevertheless much impressed by the friendliness of all these men and their wholehearted devotion to science. They were all clearly working on problems that had been planned by scientists who were free from undue political control. In fact, they had been able to carry on during the war scientific work of a kind that would have been impossible in the United States. A great deal of the work was of long-range character, which was often planned to lay sound foundations for postwar industrial developments. They had been able to defer men from active military service for such work, whereas in America it had often been impossible to get men deferred even for essential war work.

The progress in science in Russia during the war was greater than we had expected. In some fields the Russians are leading the world. The advance in scientific knowledge in agriculture, especially in soil chemistry, has been remarkable. The geological work done in Soviet Asia alone is estimated to have exceeded that done by the British government in India by perhaps fifty times.

Kapitza's laboratory in Moscow, which is superbly equipped, is devoted to the study of extremely low temperatures and to the large-scale liquefaction of gases. Several scientific discoveries of great importance have been made during the war in connection with the extraordinary properties of liquid helium, which behaves as if it consisted of two mutually interpenetrating liquids that have separate properties and can move independently of one another. This work has no apparent industrial applications.

Kapitza told me in considerable detail of a huge project to use nearly pure oxygen instead of air in the operation of blast furnaces and Bessemer converters in the manufacture of steel. From tests already made he concludes that the output of a blast furnace of a given size can be increased about fivefold by the use of oxygen, and the duration of a "blow" in the Bessemer process is cut to one-tenth. He estimates that the over-all cost of steel production will be reduced 30 percent. A $100,000,000 pilot plant to operate one or more blast furnaces continuously was nearly complete, and plans were being considered for the use of oxygen in the whole Soviet steel industry, which would involve capital expenditures of about $2,000,000,000.

Very great progress has also been made in other fields of science. Some excellent work has been done on synthetic rubber and on some plastics that are particularly good electric insulators.

On the whole, I believe that Russian scientists, except in a few fields, have not progressed as far as those of England and America. They are, however, embarking on a scientific program larger than is contemplated by any other government, and with their pioneering spirit, enthusiasm, and universal appreciation of the value of science, I believe that they may well forge ahead at a faster rate than we shall.

During the years 1934 to 1941 the Soviet government realized fully the dangers of German aggression. Instead of adopting a policy of appeasement like that of other governments they started a tremendous program of military preparation which enabled them ultimately (with only 8 percent of equipment supplied through lend-lease) to drive back the German armies from Stalingrad to Berlin. This was done by sacrificing the

higher living standards that would otherwise have been possible.

I lived in Germany as a student from 1903 to 1906 and made many subsequent visits to that country. I was always disturbed by the aggressive, militaristic spirit of the Germans, by their ideas of racial superiority, and especially by their belief that moral scruples should have no place in international relationships. One prominent German told me in 1921 that he considered the United States government criminally negligent in not fortifying the Canadian border.

In Russia there is an entirely different spirit. All the people that I met have a real desire for security against aggression and for world peace. Several of them in addresses at a session restricted to Academy members and their foreign guests emphasized that science had always been international in character—all nations had profited by the free interchange of knowledge; they hoped that similar cooperation in other fields would be possible.

Typical of many of the expressions of good will was the following toast proposed by our Soviet host at Yakutsk in Siberia as we were stopping en route from Moscow to Fairbanks:

To the Soviet Academy of Sciences,
To our scientist guests, and
To the Soviet Union,
In behalf of eternal peace.

INSTITUTIONAL AND PERSONAL EXHIBITS

The Science Exhibition, Boston Meeting, December 26–31, 1946

The Science Exhibition at the Boston Meeting will consist of commercial and nonprofit exhibits. This notice concerns the latter only; that is, those exhibits furnished by institutions or individual investigators to portray advances in various fields of science and to demonstrate new techniques and apparatus for teaching or research. The Committee on Exhibits, wishing to encourage the presentation of nonprofit exhibits, has instructed the Director of the Exhibition to make the following announcement:

Both nonprofit and commercial exhibits will be housed in the First Corps Cadet Armory opposite the Hotel Statler, which will be the headquarters of the Boston Meeting. With possible exceptions to be made at the discretion of the Committee, the space to be provided for each exhibitor will be ten feet wide. All booths will be six feet deep and will have a ten-inch shelf all around. Illustrative materials can be tacked or hung on the plywood backs of the booths. No charge will be made for the use of these booths. General illumination, necessary electrical outlets, two chairs, uniform name signs, and general service will be furnished without cost to the exhibitors. They will pay only for preparation, transportation, and installation of their exhibits and for any special construction or extra furniture that they may require for their booths. A decorating firm will provide such special materials and services at regular rates.

Those who are interested in exhibiting at the Boston Meeting should immediately request application forms from:

Theo. J. Christensen
Director of the Science Exhibition
A.A.A.S.
Massachusetts and Nebraska Avenues
Washington 16, D. C.

The closing date for receipt of applications will be September 15, 1946. Applications will be considered by the Committee as soon as possible after that date. Preference will be given to proposals that show originality in subject and method of presentation, and to exhibits that will be attended by a demonstrator. Applicants will be notified promptly of the action of the Committee.

THE RESPONSIBILITIES OF HEALTH-PHYSICS

By KARL Z. MORGAN
MONSANTO CHEMICAL COMPANY, KNOXVILLE, TENNESSEE

WITH each passing year, life on our planet becomes more intricate; man is made the guardian of greater responsibilities, and with a better understanding of the universe he is acquiring an almost incredible power for good or for evil. Man is faced with many new problems introduced by developments in the physical sciences. Sometimes in retrospect it appears that man somehow finds the right answers, and there is danger of our being lulled into the belief that in the nick of time man will always choose the proper course to nourish and preserve those things we cherish. Our forefathers had their problems of individual preservation but they were not entrusted with instruments capable of such mass destruction as we are today. We have learned to enjoy the excitement of delving into the unknown and of seeing unraveled before our eyes the mysteries of creation. Life must have seemed just a bit monotonous to Professor Michelson at the University of Chicago in 1894 when he made the statement that the underlying principles of the physical sciences had been firmly established and that future truths were to be looked for in the sixth place of decimals. The following year, on November 8, 1895, W. C. Roentgen discovered the penetrating radiation which was called X ray and thereby introduced to man the first entity of the atomic age.

Half a century later, on December 2, 1942, in the Metallurgical Laboratory at this same University of Chicago, the atomic age was really born into the world. Here for the first time man constructed and operated a self-maintained nuclear chain reaction. This was a great day for the physicists. For ages man had sought the secret of the sun's energy and a practical means of converting one element into the other. Here was a pile of uranium and graphite undergoing a controlled thermal chain reaction and giving off energy in a manner similar to the high-temperature light element chain reaction on the sun, and in the process relatively large amounts of various elements were being produced as many billions of uranium atoms fissioned each second.

At the very beginning of the Metallurgical Project[1] at the University of Chicago it was realized that unprecedented health problems would be encountered. Some of the scientists had considerable apprehension and doubt as to whether such operations as were proposed could be undertaken without enormous risk to the lives of persons employed on the projects. Dr. A. H. Compton, the director of the Metallurgical Project, recognized the importance of the hazards presented and employed the services of the eminent radiologist, Dr. R. S. Stone, as associate project director for health. Dr. Stone had had years of experience in radiotherapy and was one of the few men who had done neutron therapy research. Sections of Medicine, Biology, and Health-Physics were organized and placed under Dr. Stone's direction. Each of these sections

[1] The Metallurgical Project became a part of the Manhattan District in May 1943. The efforts of the various projects of the Manhattan District were coordinated by the United States Engineering District. It was its responsibility to integrate the numerous activities and to expedite all efforts toward the production of the atomic bomb. Col. S. L. Warren was made responsible for coordinating the health activities of the Manhattan District.

played an important part in maintaining the morale and in protecting the lives of the thousands of persons who were employed on the Metallurgical Project, later known as the Plutonium Project. My purpose is to describe the functions of Health-Physics, and so the other sections will not be discussed further here, other than to state that each was an efficient, effective, and vital part of the over-all program.

E. O. Wollan directed the first Health-Physics Department,[2] which actually began operation at the University of Chicago a few months before the Health Division was organized. Other Health-Physics departments were organized at Oak Ridge, Tenn., in 1943 and at Hanford Engineer Works, of Richland, Wash., in 1944. At present, J. E. Rose is head of the Health-Physics Department in Chicago, K. Z. Morgan at Oak Ridge, and H. M. Parker at Richland.

The purpose of the Health-Physics departments was to make a study of penetrating radiations and to devise physical means of preventing damaging exposures to personnel. This was an important assignment requiring the training of many men in this field; the development of a large number of new instruments; the pursuance of many problems of academic and development research; and the establishment of organizations to be responsible for radiation surveys and personnel monitoring. Past experiences with radiation hazards were not very encouraging. Penetrating radiations produced their damage so insidiously and inconspicuously at first that men had seldom been aware of receiving excessive radiation until they began to suffer from radiation burns or until years later they were victims of the great scourge cancer. In fact, a man in Chicago was attempting to find a cure for his X-ray burns only a month after Roentgen announced the discovery of X-rays. Past records indicated that thousands of people, including dial painters, physicians, dentists, physicists, technicians, manufacturers, and engineers, had been injured by X-rays and radiation from radioactive substances and that many had died from these effects. The evidence was that all these radiation injuries and deaths were unnecessary and could have been avoided. Many radiologists, radiotherapists, physicists, and others had suggested precautionary measures, but no organized effort in this direction had been made. If the suggestions by such men as S. Russ, who made certain radiation protection recommendations to the British Roentgen Society in 1915, had been considered seriously, it is possible that many of the unfortunate radiation injuries that occurred during and after World War I could have been avoided.

In the past, a few men on rare occasions had worked with one or two curies of radium at a time, but in the new operations with uranium piles and in the separation of the approximately thirty fission-produced elements from the uranium and plutonium, it was necessary to work with unheard-of numbers of curies of radioactive material as a routine procedure. Men had to be protected from radiation so intense that a fatal exposure could be received in an extremely short interval. Not only was there the problem of X-rays and gamma rays, beta particles and alpha particles, but there were neutrons of all energies, ranging from a fraction of an electron volt up to several million electron volts. When the first pile began operating in December 1942, there were many Health-Physics problems to be solved. It was realized that it was necessary not only to protect those men working on the projects but also to make certain that

[2] The word "department" will be used in place of "section" in the rest of this paper because an academic nomenclature more nearly describes the organization. Actually, most of the organizations had an industrial line organization of divisions, sections, and groups.

the areas about the plants were not contaminated and that the neighboring communities were properly protected. Unprecedented precautions had to be taken lest the unfortunate radiation experiences of World War I be multiplied manyfold in World War II.

THE first uranium-graphite pile operated in the West Stands of the University of Chicago in December 1942 had to be maintained at a very low power level because it was an experimental model. It had not been designed with facilities for dissipating large amounts of heat, and it was not felt safe to go higher because of the danger of the radiation to personnel in and around the building. After the successful operation of this experimental pile, plans were soon under way for the construction of the Clinton Laboratories pilot production plant at Oak Ridge and the large production units at Hanford.[3] One of the early responsibilities of Health-Physics was to check the plans of these new plants in order to make certain that the shielding about the pile units was adequate. The specifications of the shielding about the cells of the separations plant had to be checked meticulously; the ventilating systems from the piles, from the cells, and from the laboratory hoods had to meet very rigid requirements; and the waste solutions had to be taken care of properly in storage tanks, settling basins, and river systems. The history of the meteorological conditions at the proposed plant sites had to be studied carefully to make certain that the settling basins would not be washed away by floods and that the radioactive elements discharged into the air and river systems would be diluted sufficiently so as not to present any hazards to neighboring communities. Uranium had been handled on a small scale by a few radium plants for many years, and there was contradictory information regarding the hazards of this element. It was up to the Health-Physicists, Radiologists, and Biologists to determine the radiation hazards involved in handling hundreds of tons of uranium and to aid in determining standards, procedures, and working conditions that would guarantee the safety of workmen.

[3] Clinton Laboratories was first operated by the University of Chicago, and its operation was taken over by Monsanto Chemical Company in 1945. Hanford Engineering Works is operated by E. I. du Pont de Nemours & Co.

The Health-Physics departments were expanded in size and in responsibilities consistent with the development of the plutonium projects. At present there is a total of about 250 persons in Health-Physics at the three sites. This number is composed of physicists, junior physicists, chemists, engineers, meteorologists, laboratorians, and technicians. The Health-Physics activities are divided in general into three parts: (*1*) Research and Development; (*2*) Personnel Monitoring; and (*3*) Surveys.

The research and development sections of Health-Physics had to aid in making calculations on the shielding thickness necessary to protect scientists and operators from neutrons and gamma rays thousands of times as intense as any man had experienced previously. This problem was somewhat complicated in that a dense material like lead is most efficient in diminishing gamma rays, a light material like hydrogen is most efficient in stopping and slowing down fast neutrons, and elements like boron and cadmium are most effective in capturing the slow neutrons. To make matters more difficult, the slow neutrons produce penetrating gamma rays when they are captured.

In an operating pile about thirty radioactive elements are created from the fission of uranium. Some of these elements, from bromine through praseodymium, were described by G. T. Seaborg in the January 1934 issue of the *Review of Modern Physics.* All these elements are beta emitters, and most of

them give off gamma rays. They have half-lives ranging from a few seconds to a few years. Four transuranic elements have been announced, and these produce alpha, beta, and gamma radiations. They have half-lives ranging from a few minutes to thousands of years. As indicated in the official Smyth report, there are at least four delayed neutron emitters with a maximum half-life of about a minute. In addition to the above radioactive elements, all stable elements that are placed in the pile become radioactive from the bombardment of neutrons (and gamma rays in a few cases). Altogether this means the production of several hundred radioactive isotopes. It is the responsibility of the Health-Physicist to calculate the tolerance of each of these isotopes when the need arises and after the biologists have obtained the necessary biological information. Tolerances must be set for the amounts of the various isotopes that may be fixed in the body, and from this information calculations made of the tolerance concentrations in the air, in the water, and for surface contamination. Plutonium has presented one of the greatest potential hazards. It is an alpha emitter of many thousand years' half-life, and its tolerance amount in the body is a microscopic quantity. This has led to a tolerance concentration in the air of amounts of the same order of magnitude as for radium.

The tolerance levels of radiation are determined by the biological damage, and this is a function of the efficiency and method of energy dissipation in live tissue, the density of ionization, and the rate at which the radiation dose is administered. The tolerance value of 0.1 roentgens per day for X-ray and gamma radiation adopted by the American Advisory Committee in 1936 has been accepted by the Plutonium Projects. Fast neutrons are more harmful than gamma rays, and the tolerance value set for them is 0.025 equivalent physical roentgens (meaning 83 ergs per gram of tissue) per day, or a tolerance flux of 200 neutrons per square centimeter per second. The tolerance for thermal neutrons has been set at 1,500 neutrons per square centimeter per second. No tolerance can be set at present for the epithermal neutrons of intermediate energy, in which the energy is not sufficient to produce proton recoils and is too great to present a large probability of neutron capture. Such neutrons do lose energy to the tissue molecules, however, and their tolerance will be determined as soon as more information is obtained from physical measurements and a better method is developed for detecting and measuring epithermal neutrons. By "tolerance" we mean the amount of radiation that is considered not to produce any biological damage. Even subtolerance radiations produce certain biological changes (cosmic rays are supposed to have some biological effects), and so tolerance radiation is not what one strives to get but the maximum permissible dose. Many other calculations and measurements such as the scattering of radiation in gases and solids, bremsstrahlen calculations, measurement of radiation from extended sources, statistical calculations, and so on are made by the Research and Development Sections of Health-Physics.

The development, testing, production, and calibration of the various Health-Physics instruments that were needed on the Plutonium Projects were important assignments of the Research and Development sections. A few of the instruments they and associated instrument sections[4] developed were:

(*1*) A differential pressure chamber called Chang and Eng for measuring fast neutrons;

[4] Some of the persons in associated sections responsible for instrument development are W. P. Jesse and T. J. O'Donnell at the University of Chicago, S. G. English, C. J. Borkowski, J. R. Brand, and N. Ballou at Clinton Laboratories, and W. P. Overbeck at the Hanford Engineer Works.

(2) adaption of electroscopes and pocket chambers to slow neutron measurements; (3) development of various types of portable Geiger-Müller Counters and proportional counters for measuring alpha, beta, gamma, and neutron radiation; (4) development of various types of dust precipitators and filter dust collectors; (5) apparatus to count mechanically in 24 seconds the contamination on the hands and feet of a person; (6) ionization chambers and GM counters to make continuous measurements of the airborne radioactive contamination in the neighborhood of the plants; (7) instruments to make continuous measurements of the radioactive contamination in the settling basins and river drainage systems from the plants; (8) instruments to measure the alpha contamination in the hoods, on table tops, in beakers, on the hands, and even in the nostrils of a person; (9) instruments to measure the radioactive iodine in the thyroid; (10) octupi GM counter systems to be located about the doors and hallways, which would ring an alarm if anyone passed by with radioactive contamination on his person or clothing; and (11) various types of monitrons which record continuously on moving paper the radiation levels in various working areas of the plants.

The experimental research work of this section is extremely varied and ranges from rather routine tasks such as testing the various types of respirators for their efficiency in removing plutonium from the inhaled air to the more difficult investigations such as developing methods of detecting plutonium in the body and the more fundamental experiments of measuring neutrino and mesotron intensities in the neighborhood of the pile. Future investigations of the physicists with cyclotrons, betatrons, and other machines that produce high-energy radiation will present many new problems in Health-Physics research.

THE principal function of the Personnel Monitoring sections is to determine the radiation exposure received by each person working on the Plutonium Projects. In keeping with this objective, special meters are made available to persons entering the various restricted areas. These meters consist of two pocket meters shaped like fountain pens which are small, low-leakage, air ionization chambers that are charged and worn during each work shift. These pocket meters are discharged in proportion to the radiation they receive and are read on a minometer at the end of each shift. They cover a range from about 0.02 to 0.2 roentgens. Another meter worn by the personnel is a film badge containing two special, dental-size films. One film covers a range from about 0.02 roentgens to about 3 roentgens, and the other can be used up to about 20 roentgens' exposure. The film badge contains an open window which permits the interception of beta rays and low energy gamma or X-rays. It is partially covered by a one-millimeter thick strip of cadmium (or silver) to harden the radiation and give a more accurate estimate of the more energetic gamma rays. At the end of the work shifts the films are developed and read with a photometer. Persons who work in the neighborhood of the piles wear, in addition to the regular films, a special neutron film which exhibits proton recoil tracks, and those tracks on the portion of the film behind the cadmium are proportional to the fast neutron exposure. These tracks on the films are counted by means of a dark-field microscope after the films have been developed. In addition to the above films, special film packets are worn in rings, in gloves, on the wrists, and on the forehead for special radiation exposure operations. Direct reading dosemeters are worn on especially hazardous operations where a day's tolerance exposure can be obtained in a few minutes. It is a rather stupendous task to distribute thousands of pocket meters and film badges each day; to read the pocket meters with a minometer; to develop and read the badge meters with a photometer; to interpret the readings; to record the radiation exposures; and to send out exposure reports to the supervisors. Special counters are used to measure body and clothing contamination, and decontamination laundries are oper-

ated for removing the alpha, beta, and gamma radiating materials from the clothing. Each garment is checked with counters before it leaves the laundry.

The work of the Health-Physics surveyor is not simply to measure the radiation level in a given area and then specify the safe working time. This is one of the surveyor's important assignments, but his responsibilities extend much further. The experienced surveyor is expected to work with the experimenter and to aid in designing experiments in such a manner as to prevent the development of hazardous radiation levels. The good surveyor is expected to have a clear understanding and a mature appreciation of the various operations in his area and to aid in solving the numerous radiation and decontamination problems as they develop. He must know where and when to look for radiation hazards. Experience has shown repeatedly that scientists, engineers, production men, and workmen are inclined to become so absorbed in their experiments and the operations at hand that they frequently forget about the insidious radiation hazards. The specialized operations of the Health-Physics surveyors have undoubtedly prevented many serious radiation exposures and probably have saved the lives of a number of the nation's important men. Nothing can look more innocent than a small 1,000-curie source of 1 Mev gamma rays, and yet it would probably cause the death of the person who inadvertently stands six inches from it for about two minutes.

The surveyor uses regularly about twenty different instruments. Most of the instruments were given special names because of security regulations. For illustration, a few of these instruments are: Chang and Eng, Lauritsen electroscope, Landsverk-Wollan meter, Parker Four-Fold counter, Zeus, Zeuto, Pluto, Cutie-Pie, Fish-Pole, X–22, Poppy, Teacart probe, and Walkie-Talkie probe. The surveyor must know which instrument to use and when to expect various types and combinations of radiation hazards. For example, he must know when to sample the air for radioactive gas, vapor, and dust; he must know if neutrons are to be expected and, if so, what neutron energies to expect; and he must know whether the radiation is uniform or localized in beams. The off-area surveyors must keep a constant check on the radioactivity of the air in the neighborhood of the plant to make certain that the radioactive xenon, argon, iodine, and suspended fission products do not at any time present a radiation hazard to the neighboring communities. A constant check must be made of the water drainage systems to guarantee that at all times the radiation level is such that it cannot harm the fish in the river systems or contaminate the drinking water of the cities downstream from the plants.

It is impossible to state the future of Health-Physics with certainty because the future of the field of atomic energy depends on several rather unpredictable decisions of this country and the constitution and decisions of a strong world government. We can speak of a future strong world government with considerable certainty because there is little doubt in this age of atomic bombs that it will come either by peaceful agreement, with the sacrifice of some national sovereignty and the strengthening and re-enforcing of the United Nations into a world federal government, or it will come by conquest and the world supremacy of the most powerful survivor of an atomic war. In any case, one is probably justified in predicting that there will be increased efforts in the field of atomic energy in this and other countries during the next ten years. During this period we might expect considerable increase in academic and development research at Clinton Laboratories, the University of Chicago, the University of California, and a few similar research

centers. In addition, cooperating groups of educational institutions[5] and large industrial concerns can be expected to make a strong bid in this field. Perhaps relatively small enriched uranium pile units can be developed and made available, at, let us say, fifty localities in this country to supplement research with cyclotrons, betatrons, Van de Graaffs, etc. We do not expect any great revolution in any of the industries in the coming decade, or that atomic energy will do more than supplement existing forms of energy, but we can believe that much industrial research will be done at various localities in developing atomic power units to furnish heat and electrical energy to isolated localities and to supply propulsion to submarines and surface ships. We would expect a large increase in the use of radioactive tracers for biological and medical research. These tracers may have considerable influence in the chemical, agricultural, steel, and petroleum industries. Many of the radioactive elements from the piles will be used in pure physics and chemistry research, and some of these elements may serve as a substitute for radium and its products in their numerous applications.

All these developments suggest the need for a considerable expansion of Health-Physics unless the nation and the world is to run the risk of catastrophic radiation damage and the death of many of the world's scientists during the coming decade. All the larger organizations that enter the atomic energy field should have their own Health-Physics departments, and the small organizations should be visited frequently by a Health-Physicist who would give necessary advice and instructions. In addition, the larger atomic energy organizations should employ the full- or part-time services of a radiologist. In general, the Health-Physics departments should report directly to the organization director or the director of health (if there is a director of health) and not work through Medicine, Biology, Physics, or any other department. Health-Physics, Biology, and Medicine should be parallel organizations, and one should not be combined with or subordinated to another; they should work with a maximum of cooperation, with the paramount objective of the protection of man from radiation damage. In case a radiation accident should occur in a small organization, the persons involved in the accident should be rushed to a radiologist, and Health-Physicists should be hurried to the site of the accident to make the necessary measurements and give proper instructions regarding evacuation and decontamination. As soon as it is suspected that a person may have received excessive radiation exposure, he should be turned over to the medical department, which takes full responsibility for the examination, care, and treatment of the patient.

These suggestions assume that there is an adequate supply of Health-Physicists and Health-Physics instruments. As a matter of fact, there is a scarcity of both, and this article is written primarily to call attention to this need. In order to meet the manpower requirements, an educational program should be set up at Clinton Laboratories and at other localities as the facilities and need arise. Already a large number of Health-Physicists have been trained at Clinton Laboratories for other sites. Such a training program should consist of two parts: (*1*) The training of Health-Physicists; and (*2*) the offering and sponsoring of a course in Health-Physics

[5] Already at the University of Chicago the Institute for Nuclear Studies, the Institute for the Study of Metals, and the Institute of Radiobiology and Biophysics have been organized for nuclear research. Similar programs are planned at the University of California and other universities. The Argon National Laboratory, the Park Ridge Institute of Nuclear Studies, and a still unnamed Regional Laboratory are in the process of organization.

to be given to all those who plan to enter the field of nucleonics, in order that they may develop the proper respect for radiation hazards. There is already considerable progress toward the establishment of an educational program in nuclear research at Clinton Laboratories in cooperation with a number of universities. Perhaps the Health-Physics educational program will become a natural part of this larger organization.

Another important general responsibility of our Health-Physics organization, such as the proposed organization at Clinton Laboratories and at the University of Chicago, should be to develop and supply Health-Physics instruments to the other organizations. It would not seem necessary or desirable that each of the Health-Physics organizations that may spring up over the country have its own research and development section or supply its own instruments. War experience has shown that industrial instrument organizations that are isolated from Health-Physics departments have not produced satisfactory instruments. Perhaps small research and development sections would be needed in some of the larger organizations to solve the problems peculiar to those plants, but in general it seems probable that an organization such as is proposed at Clinton Laboratories or at the University of Chicago would be able to supply most of the initial Health-Physics instrument needs and could furnish the nucleus of a trained Health-Physics personnel. In case of an explosion in an atomic energy plant or in the event of an atomic war, the need for Health-Physicists and their instruments would be very urgent, and they must be available on short notice.

The Health-Physics departments on the Plutonium Projects feel that their existence has been, and will continue to be, justified. So far as the Medical departments can determine and insofar as the Health-Physics instruments can measure, no one has received any radiation damage on any of the three Plutonium Projects. This statement is made with fingers crossed and with the realization that overconfidence or lack of vigilance could lead to great loss of life in a single day. Credit for the success of this program should be given to the 250 men in Health-Physics, and to the cooperation of the thousands of men in other departments. Special mention should be made of the assistance of the Medical Directors, J. E. Wirth at Clinton Laboratories, S. T. Cantril at Hanford, and L. O. Jacobson and J. J. Nickson at the University of Chicago.[6] Regardless of the trend of developments in the near future, there seems to be an ever-increasing need for Health-Physicists. Young men with college degrees and majors in physics should be encouraged to go into this field, and an educational program should be initiated to facilitate this training. In production plants, where the principal emphasis is placed on personnel monitoring and plant survey, a physics background is less important than it is in a research institution, and experience has proved that high-class chemical engineers can be trained to become excellent Health-Physicists for radiation survey assignments. Also chemists, biologists, engineers, and other technical personnel should consider training for various assignments in this new field of Health-Physics. The efficiently operated Health-Physics organization at Richland, Wash., should serve as a model for that of other large plants producing atomic energy.

[6] A few of the Health-Physics group leaders who also deserve special mention are W. H. Ray, R. H. Firminhac, L. J. Deal, and R. R. Coveyou at Clinton Laboratories, F. R. Shonka and O. G. Landsverk of the University of Chicago, and C. C. Gamertsfelder, J. C. Hart, C. M. Patterson, and Jack Healy of Hanford.

WHAT SOUND HATH WROUGHT—I*

By NATHAN LEVINSON

WARNER BROS. PICTURES

TWENTY years ago, on the evening of August 6, 1926, a critical New York theater audience viewed and approved the initial exhibition of the world's first commercially successful sound motion picture. Preceded by a screen address by Will Hays and a series of sound short subjects featuring such artists as Marion Talley, Anna Case, Martinelli, Mischa Elman, and Zimbalist, the first feature sound picture, ***Don Juan,*** brought its own orchestral accompaniment to the screen through the medium of Vitaphone recordings, which were reproduced in exact synchronism with the picture. Thus, after months of most intensive preparation, the Warner brothers presented to the public a new medium of entertainment, which was shortly to bring an end to the era of silent motion pictures.

Some six months later William Fox demonstrated results which had been achieved by the photographic recording of sound on film, and shortly thereafter he introduced the Fox Movietone Newsreel employing a photographic sound track. On October 5, 1927, the Warner Brothers Vitaphone Corporation released *The Jazz Singer* starring Al Jolson, containing the six spoken words which electrified the industry. Judged in the light of events which followed, the success of *The Jazz Singer* apparently provided the proof necessary to the major motion-picture producers of Hollywood that sound pictures had come to stay, and plans for the construction of soundproof stages and the installation of sound-recording equipment were rushed to completion with a wholehearted disregard for costs. Engineers, technical advisers, and technicians were rushed to Hollywood from the East to assist in the revolution of the motion-picture industry. Manufacturers of sound-motion-picture recording and theater equipment worked extra shifts in an attempt to meet the sudden demands of a new industry. By the end of 1928 a total of sixteen sound-recording channels had been installed in Hollywood; by the end of 1929 this number had grown to at least one hundred and sixteen. New motion-picture production techniques were developed overnight. The Academy of Motion Picture Arts and Sciences established a sound school which provided instruction in the new art of motion-picture sound recording to more than nine hundred men. Schools of voice culture grew in sheer profusion, motivated by a desire to assist, for a price, those stars of the silent screen whose vocal prowess was somewhat inferior to their mastery of the art of pantomime.

LEST it be assumed that the sound motion picture was the result of a single and spectacular technical achievement, it should be pointed out that it was brought to a state of practical realization largely through the simultaneous development of a number of rather unrelated discoveries in the field of pure science. Numerous attempts to exhibit sound motion pictures were made between the year 1878, when Wordsworth Donesthorpe suggested the idea of talking photographs, and the year 1924, when

 This article was obtained through the cooperation of Mr. Charles S. Steinberg, of Warner Bros. Pictures, the company that is now celebrating the twentieth anniversary of its successful introduction of sound motion pictures.—Ed.

the Bell Telephone Laboratories demonstrated its newly perfected motion-picture recording and reproducing systems. With few exceptions, the failure of the various systems proposed and experimentally constructed during those early years was due to a lack of one or more of the elements considered essential to any modern recording and reproducing system.

The practical beginnings of the talking picture date back to the year 1877, when Thomas Edison announced his development of the phonograph. It was within a year of that date that Donesthorpe suggested the talking photograph. In a letter to *Nature*, which was published in the issue of January 24, 1878, Donesthorpe stated:

> By combining the phonograph with the Kinesigraph I will undertake not only to produce talking pictures of Mr. Gladstone which, with motionless lips and unchanged expression, shall positively recite his latest anti-Turkish speech in his own voice and tone; not only this, but the life-size photograph itself will move and gesticulate precisely as he did when making the speech, the words and gestures corresponding as in real life.

Donesthorpe took his photographs at intervals of approximately $\frac{1}{4}$ second, with an exposure of $\frac{1}{8}$ second, which probably accounts for his use of the phrase "with motionless lips and unchanged expression." Unfortunately, the Edison phonograph of 1880 had not been brought to a high state of perfection, and nothing came of Donesthorpe's experiments.

Although the production of photographic sound records presented numerous difficulties not inherent in the mechanical process of recording, it is interesting to note that Charles E. Fritts, on October 22, 1880, filed a patent application which covered a variety of photographic sound records, several of which are basically similar to modern motion-picture sound track. Fritts proposed that these sound records might be reproduced by causing a narrow beam of light to pass through the moving sound record and then to fall upon a selenium cell, which would regulate an electric current and thus operate a diaphragm. Fritts' patent was finally issued on October 21, 1916, a full thirty-six years after it was first embalmed in the archives of the United States Patent Office.

Contrary to popular impression, it was not the development of motion pictures that gave rise to a desire for an accompanying sound record, but the development of the phonograph that led Edison to the idea that "it was possible to devise an instrument that would do for the eye what the phonograph does for the ear, and that by a combination of the two all motion and sound could be recorded and reproduced simultaneously." Edison pushed the development of his motion-picture machine and by April 1894, with the aid of some of George Eastman's first strip film, produced sound motion pictures of the peep-show variety.

Although the Edison Kinetophones, as these peep-show devices were called, were not commercially successful, he continued the development of his equipment and, by the year 1908, had produced a sound-picture system designed for use in the comparatively large film theaters which by that time had made their appearance. This theater system consisted primarily of a motion-picture projector, which was located at the rear of the theater, and a phonograph, which was located on the stage and driven in approximate synchronism with the projector by means of a long wire belt. This system seems not to have created any widespread public interest and effectively disappeared from the scene within a few years from the date of its introduction.

The period between the years 1900 and

1924 witnessed a number of significant experiments directed toward the achievement of satisfactory reproduction from disc and film sound records. Prominent among the pioneers in sound-picture development are the following men: Ruhmer, who experimented with means of photographing a voice-modulated arc light on motion-picture film; Poulsen, who developed a method of magnetic sound recording on a steel ribbon; Gaumont and Lake, who experimented with various systems for synchronizing phonographs and projectors and who also suggested the use of loud-speakers behind the theater screen; Amet, who employed electrical pick-up methods for recording; and Lauste, who pioneered in the development of methods for recording the picture and sound on the same strip of film. In the latter years of this period such names as Case, Hoxie, and De Forest were added. A study of the patent literature of that period reveals that the number of investigators engaged in the development of recording, reproducing, and synchronizing methods was exceeded only by the diversity of their ideas on satisfactory methods of accomplishing their objectives.

Of the hundreds of early experimental attempts to develop a satisfactory sound-motion-picture system little remains today. Without exception, each of the proposed systems was deficient in one or more important respects when judged by the form of the first commercially successful equipment. Edison's principal contributions, of course, were the development of the phonograph and the motion-picture machine; his actual attempts to produce commercial talking pictures have had no noticeable influence on later developments. Fritts indicated a variety of sound photographic records and means for reproducing these. Several of his proposed types of sound track are in widespread use today, but his system of reproduction was wholly inadequate to meet commercial theater requirements and had no perceptible influence on the development of modern reproducing equipment. The invention and development of the telephone was, on the other hand, essential to the practical achievement of sound motion pictures, as were the invention and development of the electron amplifier tube, the photoelectric cell, and the loud-speaker. The modern sound motion picture is actually a hybrid of developments in such fields as electronics, acoustics, chemistry, mechanics, optics, and metallurgy.

It would be impossible to properly assess the value of contributions made by individual inventors to the sound-motion-picture industry. Much of the necessary research and development work essential to the evolution of modern commercial recording and reproducing systems has been conducted in the laboratories of our larger industrial organizations. In particular the Bell Telephone Laboratories and the research divisions of the General Electric Company, the Westinghouse Electric Company, and the Radio Corporation of America may properly be credited with the fundamental and major contributions to the art.

Although the first commercial sound-motion-picture equipment emerged from the laboratory in the year 1926, a continued program of research and development, leading to the improvement of equipment originally installed in the Hollywood studios and in the theaters throughout the country, has been maintained. Additional development work, stimulated by the problems encountered in adapting recording and reproducing equipment to the ever-changing needs of the motion-picture industry, has been carried on in the major motion-picture studios of Hollywood.

The first commercial sound-picture records were derived from recordings made upon finely polished soft wax blanks. After suitable processing of these waxes, a "stamper" was produced which permitted the production of quantities of release records in the form of sixteen-inch discs, similar in all respects save size to those utilized with the home phonograph. Each disc record carried an engraved start mark, which permitted its proper synchronization with a corresponding reel of picture in the theater projection machine.

At the time of the introduction of sound motion pictures the technique known as dubbing, which consists of combining portions of a number of individual records into a single final release record, had not yet been developed. It was necessary, therefore, to so arrange all the elements involved in the production of a picture that photography and recording might proceed continuously for the period of eight to eleven minutes required to complete a single reel of picture. When more than a single scene was included in a reel, it was necessary to provide the requisite number of motion picture sets adjacent to one another and to secure smooth sound and camera "dissolves" from one scene to the next without halting the recording machines or cameras. This situation imposed almost intolerable production restrictions, and means were soon developed which permitted electrical re-recording of portions of a number of individual original records to a final release record, without loss of synchronization between sound and picture at any point of the process.

Between the years 1928 and 1931 disc recording gave way to photographic recording on motion-picture film, and with this transition the most severe handicaps imposed upon motion-picture production by the advent of sound were eliminated.

Almost all motion-picture production techniques have undergone extensive modifications since the transition from silent to sound picture releases, and a review of some of the changes wrought by the introduction of sound may prove of interest.

The motion-picture industry has long been symbolized in the minds of the movie-going public by cartoons of the motion-picture director with megaphone raised to his lips. It is difficult to state whether the megaphone represented a necessary accessory to the direction of silent pictures or whether it served merely as a badge of honor, but it is known that the noise levels encountered on stages employed for the production of silent motion pictures was of such an order as to preclude the production of sound pictures. The silent-picture stages were, in most cases, of relatively light construction, since they were designed primarily as a shelter for interior sets and to permit the attainment of a degree of lighting control which could not be secured in the open. As a general rule exterior sets were built in the open and in any location which might prove convenient from a production standpoint. Noise, as such, was troublesome only to the extent that it might be considered annoying to the artistic temperaments engaged in the production of a picture.

With the introduction of sound recording the elimination of extraneous noises from the motion-picture set became a matter of vital importance to production. It was necessary, therefore, either to modify the construction of existing stages so as to provide complete freedom from traffic and other exterior noises or to construct stages specifically designed for the production of sound pictures.

Modifications to existing stages consisted primarily of soundproofing the walls and ceilings and eliminating squeaky floors. New stage designs pro-

vided for structures which were inherently rigid and sufficiently well insulated to provide very high attenuation to all sounds transmitted through the walls and ceilings. The necessary insulation was generally obtained through the use of laminated walls which consisted of alternate layers of rigid and porous materials, separated by air spaces. Flaxlinum, celotex, and rock wool were widely used as insulating materials, and it is interesting to note that the sudden demand for huge quantities of these materials stimulated the expansion of manufacturing facilities for their production. Few of the new stages had more than two large doors, and these were of laminated construction similar to that employed for the stage walls. While the size of the various new stages differed considerably, a typical sound stage provided a floor area approximating 30,000 square feet, the average structure being of the order of 225 feet in length, 135 feet in width, and from 35 to 50 feet in height.

The amount of power required for set lighting purposes during the early years of sound recording was rather appreciable, three to four thousand kilowatts being employed for many of the larger sets. In view of the fact that more than 95 percent of this power was converted into heat, adequate stage ventilation was essential. A number of stages were equipped with air-conditioning plants, while others employed large roof ducts which were suitably lined with felt or other sound-absorbing materials.

Acoustic treatment of the interior stage walls was generally such as to minimize reverberation effects to the point where these were not troublesome. It has not been customary to provide adequate acoustic treatment on sound stage walls to permit high-quality recordings on empty stages.

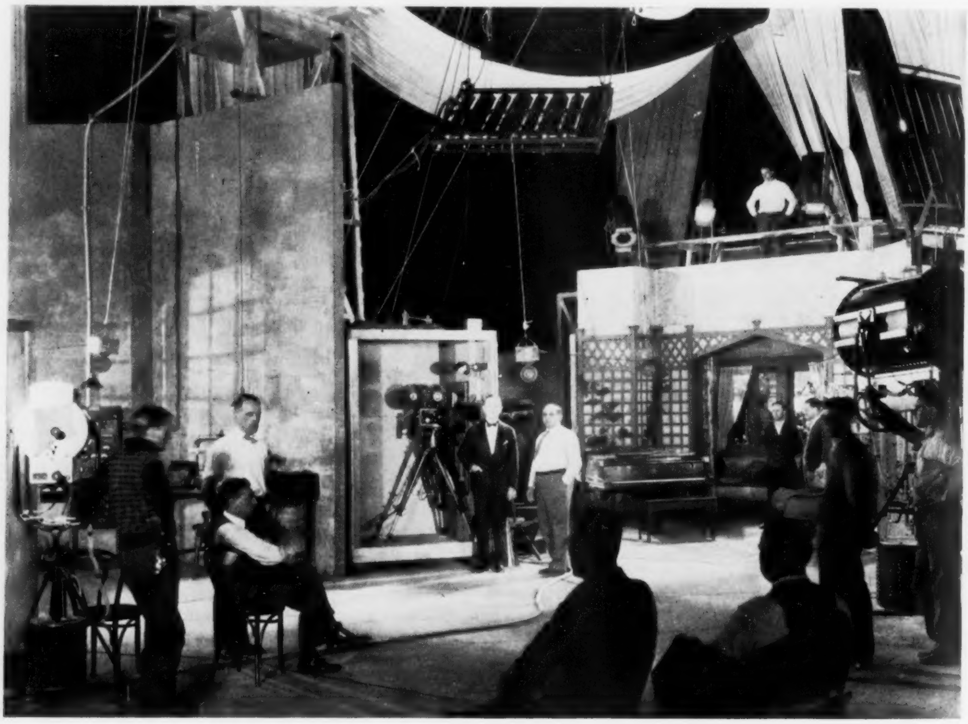
The earlier forms of studio sound-recording equipment were far from portable. The microphones and their associated amplifiers, mixer equipments and booster amplifiers, and monitoring amplifiers and loud-speakers were installed on the stages, while the main recording amplifiers, recording machines, power supplies, and auxiliary apparatus required for the sound-recording channel were located in central recording buildings. Underground circuits were employed to connect the equipment used on the stages with that in the recording building. Thus, each stage had to be equipped with numerous signal, power, and communication circuits and with suitable terminations for these circuits at a number of points on the stage. The microphones and their associated amplifiers were so located on the actual set as to permit the best possible pick-up of voices and such incidental sounds as were required for the scene being photographed. The remainder of the stage equipment was at first located in so-called monitor rooms, which housed the sound-mixer equipment, amplifiers, monitoring loud-speakers, and such other auxiliary apparatus as were necessary to permit proper control of the signals being transmitted to the central recording building.

In a number of cases these monitor rooms were constructed at a sufficient elevation above the stage floor level so that the sound mixer, who controlled the over-all signal level and combination of sounds from the several microphones employed, would have an unobstructed view of the set engaged in production. It was soon found, however, that the view from these monitor rooms was frequently blocked by large set structures, and accordingly the use of monitor rooms soon gave way to portable monitoring booths which could be placed immediately adjacent to the set being employed.

One of the greatest difficulties encoun-

tered in the production of satisfactory sound records was caused by the various noises originating on and about the motion-picture set proper. Perhaps one of the worst offenders in this respect was the motion-picture camera itself, whose constant whirring was not only audible but in many cases tended to blanket the dialogue picked up by the microphones. The first solution to this problem took the form of soundproof booths, large enough to house one or two cameras and the cameramen who operated them. A total of three or four such camera booths might be employed in the photography of a single scene.

As increased production freedom was provided through the development of improved sound-recording equipment, and in particular with the displacement of disc recording by film recording, the restrictions on camera operation imposed by the camera booths became intolerable. Practically full freedom of camera operation and manipulation was regained during the year 1929 by the use of housings, known as camera blimps, which completely enclosed and soundproofed the camera but permitted its operation on standard tripods, dollies, or cranes. Somewhat later, further improvements resulted from developments by motion-picture camera manufacturers who bent their efforts to the production of inherently silent camera mechanisms. As a result of this program, and after years of laboratory and studio experimental work, the modern professional motion-



EARLY MOTION-PICTURE SOUND EQUIPMENT

A TYPICAL OFF-STAGE SETUP IN 1926 FOR THE FILMING OF A SCENE. NOTE THE OLD-FASHIONED, OVERHEAD, CARBON-TYPE MICROPHONE AND THE MOTION-PICTURE CAMERA INSIDE THE SOUNDPROOF BOOTH.

picture camera is so quiet in operation that it can be operated on any indoor motion-picture set without the aid of auxiliary soundproofing enclosures.

The modifications of the camera mechanism necessary to subdue noises generated by gear trains, intermittent mechanisms, motors, and the passage of film through the camera have also greatly improved the quality of the photographic image and the clarity and steadiness of the picture viewed on the theater screen. Here, then, is evidence of several very desirable improvements which were at least initiated by the introduction of the talking picture.

The motion-picture negative film employed at the time of the introduction of sound pictures was of rather low sensitivity as compared to the modern product, and large banks of arc lamps were generally employed for set illumination. The operation of these lamps was accompanied by intermittent sputtering noises, squeaks and groans from the carbon driving motors and mechanisms, metallic popping noises caused by expansion and contraction of the lamp housings due to high thermal gradients, and whining noises characteristic of the commutator ripple originating in the generator sets which supplied power to the lamps. Hasty remedies were improvised for removing most of the noise produced by the operation of lamp mechanisms, and various forms of large and clumsy choke coils and other filter devices were utilized to subdue the whine produced by commutator ripple. Only a moderate degree of success was attained, however, and experiments leading to the utilization of incandescent set lighting were hastily initiated. All types of incandescent lighting equipment were exhaustively tested by studio technical personnel, assisted by engineering representatives from the large incandescent lamp manufacturers. Warner Brothers Studio, which was pioneering in the development of talking pictures, offered its studio facilities to members of the American Society of Cinematographers in order that the necessary photographic tests might be made to establish a basis for the attainment of satisfactory photographic quality. During one period of sixty days over three hundred cinematographers assisted in experiments and attended demonstrations leading to the development of incandescent set lighting.

The largest incandescent lamps available at the time of these experiments were 1,000-watt units, and these were employed individually and in banks to secure the necessary illumination levels. Somewhat later, 2,000-watt lamps, employing a monoplane filament and prefocused bases, were developed to meet the specific needs of the motion-picture industry. Five- and ten-thousand-watt lamps, employing bipost bases, were developed at a still later date. These lighting units proved so satisfactory that arc lamps were employed only when it was necessary to provide the high lighting intensities required for color photography or for black-and-white production scenes requiring the high illumination levels or sharply outlined shadows which only arc lighting can provide. It should be added that continued development of arc lamps and properly designed filter networks for the elimination of commutator ripple have relieved most of the objections to the use of these lamps, and, in view of their superiority over incandescent lamps for certain lighting applications, they are still widely employed in the industry. During the year 1942 a suitable compact filter was developed at Warner Brothers Studios which efficiently and completely eliminates all commutator ripple noise from arc lamps in service. Thus, the introduction of sound recording forced rather revolu-

tionary changes in the techniques and equipment employed for motion-picture set lighting.

During recent years film manufacturers have succeeded in so improving the sensitivity of motion-picture negative stocks that present-day set lighting intensities are comparable with lighting values employed in many commercial operations. A pronounced trend toward the use of low wattage spotlights, in conjunction with main lighting elements employing 1,000- and 2,000-watt lamps, has resulted in a very appreciable reduction in the amounts of power required for set lighting as compared with that used twenty years ago.

The character of the sets required for the production of sound motion pictures was materially different from that suitable for silent productions. The nature of the materials employed for the construction of silent-picture sets was dictated largely by the cost and availability of materials and the nature of the illusion which might be created through their use. With the introduction of talking pictures it became necessary to consider the acoustic qualities of the materials employed and to avoid set structures of such configuration as would produce resonances or reverberation effects. It was essential, for example, to minimize the use of alcoves and arches and to avoid wherever possible the construction of sets with deep window recesses. Pronounced reverberation effects were also evident in sets constructed with vaulted ceilings, unless these were fabricated of muslin. The use of beamed ceilings was avoided wherever possible, for it was necessary to provide adequate space above the set for unrestricted movement of the recording microphones.

For a time it was believed that set walls should be almost entirely constructed of cloth, and a great many were so constructed. Within recent years walls have commonly been constructed of plywood mounted in suitable wooden frames, the objection to continued use of cloth walls arising largely from the fact that they have no salvage value, nor do they provide the rigidity so often essential in set construction. In order to avoid the flutter of cloth set walls it is necessary to provide suitable reinforcing backings of wood. These backings are also required whenever objects, such as pictures and clocks, must be suspended from the walls.

The rather loud and frequently boomy sounds of footsteps on the hardwood stage floor have been reduced to inaudibility through the use of broadfelt floor coverings. Materials such as celotex have found a great variety of applications in set construction, being employed, for example, in place of concrete for building exteriors, sidewalks, and flagstones. Many of the most massive structures viewed on the screen of the motion-picture theater are built of such comparatively fragile materials as papier-mâché, fabrics, and plywood. The choice of the materials employed is, of course, based upon a number of considerations, among which might be included mechanical strength and rigidity, ease of fabrication, cost and availability of materials, size of the structure involved, freedom from panel vibration and other objectionable acoustic characteristics, and suitability from a photographic standpoint.

Some idea of the magnitude of the single task of designing and fabricating sets for one of the major motion-picture producers may be gained from the number of studio employees engaged in this work. The production of twenty feature pictures a year requires the full-time services of an average of fourteen art directors, twelve sketch artists, seven model builders, thirty set designers, one

hundred and fifty carpenters, one hundred and twenty-five painters, forty machinists, and approximately one hundred men who are engaged in crafts involving smaller numbers of workers.

A number of the departments now of major importance to the operation of a modern motion-picture studio were scarcely in existence prior to the advent of sound. One of these is the Story Department, whose function is that of securing suitable material for the production of the large number of feature pictures and shorts which are released each year. Silent motion pictures were often shot with incomplete scripts and in many cases without the benefit of any script at all. A clever director and cinematographer could undertake the production of a feature picture with a script which provided only the general framework of the story involved. Such dialogue as might be incorporated in the script was relatively unimportant, since titles were used to convey such information to the theater patron as could not be readily gained from the action involved in the picture.

This method of production required radical modification with the introduction of the sound picture. In the first place, the dialogue involved was, in many cases, of equal or greater importance to the sense of the story than the action of the players, and it became necessary to prepare production scripts complete to the smallest detail to permit satisfactory direction of the picture. A complete script was also essential in order that the studio Art Department might undertake the design of sets suitable for production of sound pictures.

The entire presentation of the average feature production has taken on a lifelike quality which was completely absent in the exaggerated pantomime of the silent picture, and characters appearing on the screen have assumed a degree of realism which was impossible in silent pictures. The scope of material suitable for screen presentation as sound pictures is enormously greater than that which could similarly be employed in silent presentation, and many situations whose entire significance is conveyed through dialogue may now be successfully portrayed. Many stage plays which were formerly beyond the scope of the motion picture have been made into very successful sound pictures. The comedy of action has generally been replaced by the comedy of wit. Many situations may be successfully portrayed without dependence upon either dialogue or action, but solely through the use of cleverly employed sound effects.

The modern Story Department maintains very elaborate files of synopses of practically all the publications in the field of fiction and employs a staff of experts to continually survey the several literary fields. The preparation of production scripts is frequently entrusted to writers with world-wide reputations, who are assisted in their efforts by Story Department personnel acquainted with the restrictions imposed by production codes and the general limitations of the medium. When detailed information with respect to some phase of preparation of the script is required, the studio Research Department is consulted. It can make available on short notice complete information with respect to the life, dress, habits, customs, beliefs and prejudices, housing, social and business activities, government, and past history pertaining to practically any community or people on earth. It is through such means that the authenticity of situations and characters depicted in many historical pictures is assured.

(To be concluded)

DOES THE STING RAY STRIKE AND POISON FISHES?

By E. W. GUDGER

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK

IN ANOTHER paper (1944) I have assembled and discussed in monographic fashion all the evidence available from classical times to 1932 that sting rays wound, poison, and occasionally cause the deaths of men. In another and shorter article now in press, I have summarized Vellard's experiments (1931, 1932) with spines from certain freshwater sting rays which abound in the Araguaya River in South-Central Brazil. With venom from these spines, he experimented on dogs, mice, rabbits, guinea pigs, birds, lizards, frogs, and toads. These were all poisoned, and many died as a result of the infections. These very interesting experiments seem to be the only ones ever made wherein the poison of the sting ray has been tried out on vertebrates or indeed on any animals. Therefore it is of no small interest to ascertain whether rays sting other fishes and whether fishes so stung are poisoned. These questions apply not only to the great group of teleosts, or bony fishes, but to the elasmobranchs, or strap-gilled fishes, including sharks and rays themselves.

BONY FISHES

The ray's sting is an organ of defense only, never of food-getting. Yet I can quote two old-time authors who thought that the sting was used to catch bony fishes for food. Thus Pliny (23 B.C.–A.D. 79) says in his *Naturalis Historiae* (Bk. IX, Chap. 67) that "The *Pastinaca* [Mediterranean sting ray] lies lurking in ambush and pierces the fish as they pass with the sting with which it is armed." And the eminent early French ichthyologist Guillaume Rondelet in his book *De Piscibus Marinis* (Lyons, 1554) speaks of the Trygon with its spine pointing backward but with the teeth pointing toward the ray's head. Then he says that ". . . when the ray has stung a fish, the spine holds it like a hook."

These statements by Pliny and Rondelet were mere inferences drawn from the presence of the barbed spine on the tail of the ray. No writer since Rondelet's time has alleged that the spine is an organ for the prehension of food. It should be noted that the ray's small ventral mouth and its flat body fit it for bottom dwelling and feeding. It feeds on worms (its chief food in my dissections), clams, and crustaceans—all small bottom-dwellers. An occasional small fish may be taken in, but fishes cannot be considered as its steady diet. Moreover, it is notable that sting rays taken in pound nets along with great numbers of bony fishes have never, so far as the records go, had any fish remains in their stomachs.

It has been alleged, however, that one of the stingless rays, *Mobula*, feeds on fishes. It was described to me by the observer as forming with its unrolled "horns," or cephalic fins, a kind of funnel and then swimming into and through a school of small fishes. The funnel directed these fishes into its huge mouth. Probably this habit of feeding is common to the other Cephaloptera, or stingless rays with cephalic fins.

So far as I know, there is no record of a sting ray striking a bony fish. This

might happen if the bony fish surprised a ray, but I cannot imagine an intentional stinging. Furthermore, no experiments with fresh sting ray spines seem ever to have been made on bony fishes. If and when this is done, one may surmise that the bony fish would be poisoned. Here is a field for interesting experimentation.

Rays

There is also no record known to me that any of the rays have ever been stung by a sting ray. I have handled and dissected scores of sting rays and stingless ones without ever finding a ray that showed any evidence that it had been stung. These rays must compete for the same food; they are found in groups and are not averse to using their stings in defense. But the record of any use of the spine on another ray is blank. No one knows whether the stinging of a ray would be followed by poisoning. Here is another opportunity for experimentation. This blank record for rays is all the more surprising in the light of what is to follow.

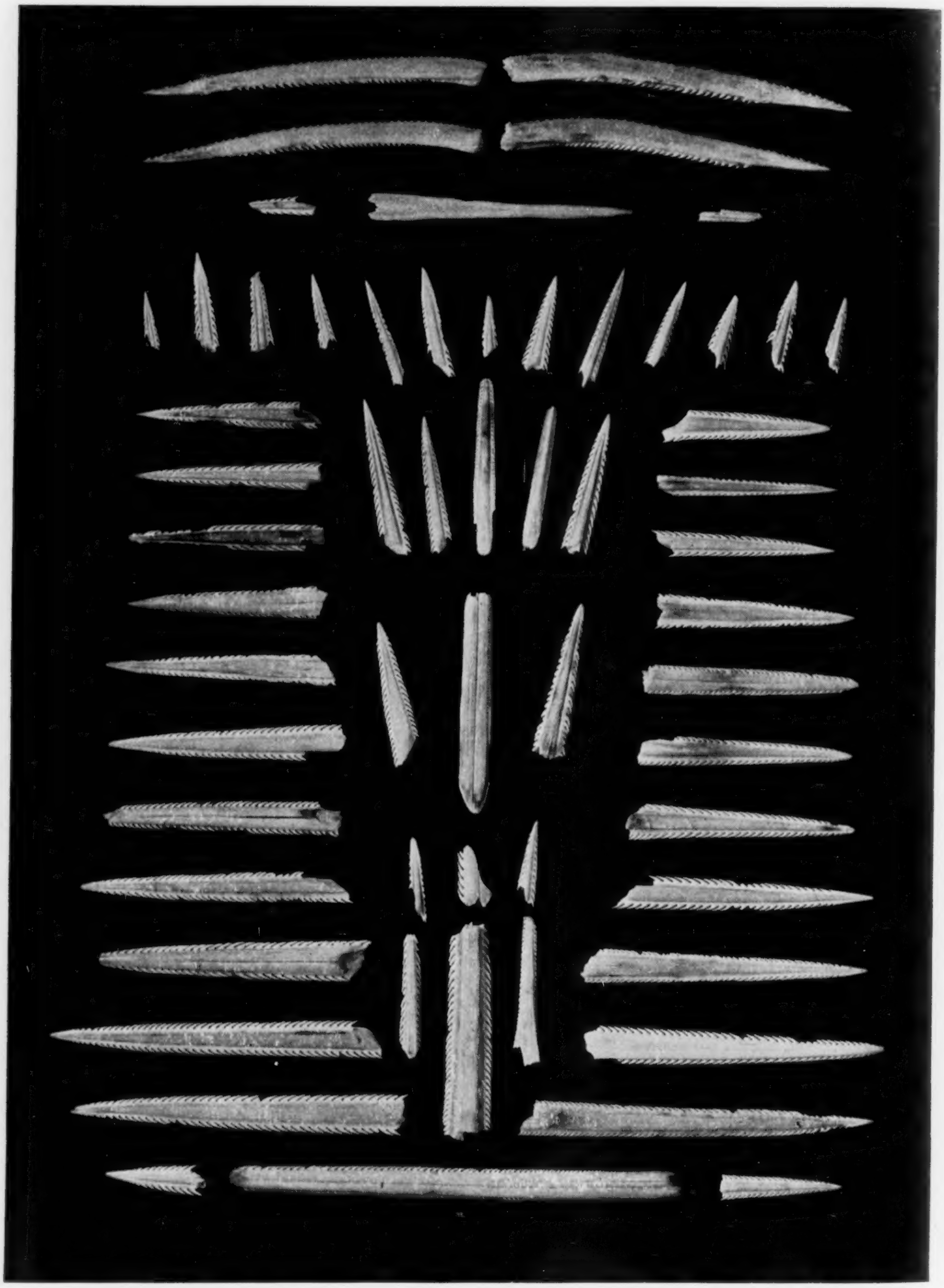
Sharks

My personal experience with sting rays and sharks began in the summer of 1902 at the U. S. Fisheries Laboratory at Beaufort, N. C., and continued there for ten seasons; it was further continued for four seasons more at Key West and at the station of the Carnegie Institution of Washington, at Tortugas, Fla. Sting rays and sharks were being sought for the study of their reproductive organs and their methods of reproduction. I was warned of the violence of the rays and of the virulence of their stings by my fishermen friends. In my ignorance, I supposed that all the water vertebrates as well as man were susceptible to poisoning by rays. That sharks were stung but not affected was not ascertained by me until 1906.

It is known that at least four species of sharks—the hammerhead, the black-tipped, the sharp-nosed, and the tiger shark—are stung but not poisoned by rays. The evidence will now be presented.

Hammerhead No. 1. On July 20, 1906, a huge hammerhead shark (*Sphyrna zygaena*) was seen chasing large sting rays over the sand flats in Beaufort Harbor. Rays and shark swung near an anchored fishing boat, and the shark (12 ft. 6 in. long) was secured with a harpoon. The next day I purchased the shark (a female), towed it to the wharf of the Bureau of Fisheries Laboratory, hoisted it by a derrick, and dissected the viscera. In the stomach was found an almost perfect skeleton of a sting ray, together with fragments of the skeletons of other like victims. In cutting the skin away from the muscles (one cannot husk the hide off a shark as from an ox) I found stings abundant in the throat and jaw region. Night came just when the skin had been literally dissected from the body muscles, and further work was stopped.

Next day, 40 hours after capture of the shark, the jaws were dissected out, even though the shark was in pretty "high" condition, and cleaned up for preservation as a museum specimen. In this dissection 54 fragmentary sting ray and 4 ocean catfish stings were found in the neck region and in the muscle masses adherent to the jaws. In the neck region some of the stings were embedded in tissues still suffused with blood, showing that the wounds were recent. Others, especially those piercing the membranes covering the jaw cartilages, were embedded in cysts, showing that they were from old stingings. Furthermore, the jaw cartilages were scarred and ridged —evidently the result of long-past combats. These jaws and adjacent parts were a real mine of stings, and yet this hammerhead was alive, unhurt, and a



After Gudger, 1932

FIG. 1. SPINES RECOVERED FROM A HAMMERHEAD SHARK

EXCEPT THE 4 PECTORAL SPINES OF THE OCEAN CATFISH AT THE TOP, ALL ARE SPINES, OR STINGS, OF STING RAYS. ALL 58 WERE DISSECTED FROM THE JAWS AND NECK REGION OF A HAMMERHEAD SHARK.

veritable dynamo of energy when harpooned. Figure 1 shows these stings arranged in a panel.

Sting rays had surely been a favorite food of this particular hammerhead. When caught in the shark's jaws, each ray had in defense lashed out with its long tail, and at least 54 of them had left with the shark mementos of their fights. Figure 2 is an excellent portrayal of *Dasyatis centrura,* a typical sting ray found at Beaufort and ranging north along our Atlantic coast. Note the two spines set some distance out on the tail, giving the ray a considerable striking radius and force. Probably rays of this species are responsible for some of the spines shown in Figure 1.

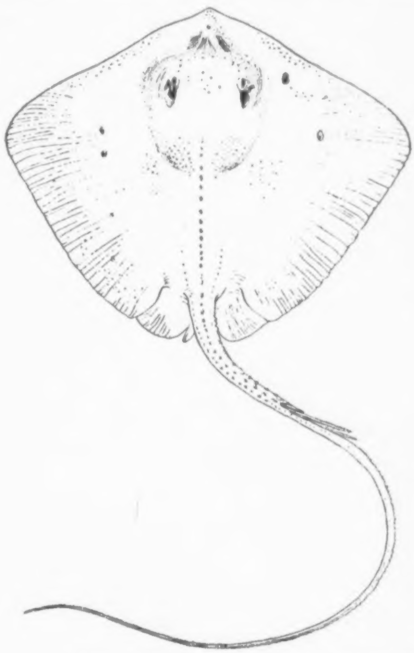
Hammerhead No. 2. Just 20 years after I made the observations set out above, Mr. Henry W. Fowler (1926) wrote of a hammerhead shark, 13.2 feet long, taken at Captiva Pass, West Coast of Florida:

> In the stomach . . . were three rays . . . with a disc length of 18 to 24 inches, and in the mouth one ray of 20 inches. There were remnants of 17 caudal spines in the stomach. . . . The jaws were punctured with other spines and at least 24 spines were in the gums.

Had jaws, neck, and chest region been dissected, many more than the 24 spines would probably have been found. Yet this shark with 17 spines in its stomach and 24 in the jaws was very much alive when captured. Its taste for rays, like that of hammerhead No. 1, was certainly well developed.

From these two detailed accounts, it is clear that sting rays are probably the favorite food of the hammerhead shark, and it seems clear that these sharks are not susceptible to the poison of the sting.

The Black-tipped Shark. The American Museum possesses a considerable collection of dried shark jaws, among them one from a black-tipped shark (*Carcharhinus limbatus*) taken at Djibuti, on the Gulf of Aden. This pair of jaws had been merely "roughed out," salted, and dried. Some years ago I had occasion to carefully dissect off this dried muscle tissue and clean these jaws for photographing. From them 13 stings were obtained. In the lower left jaw a sting



After Hildebrand and Schroeder, 1928

FIG. 2. A STING RAY

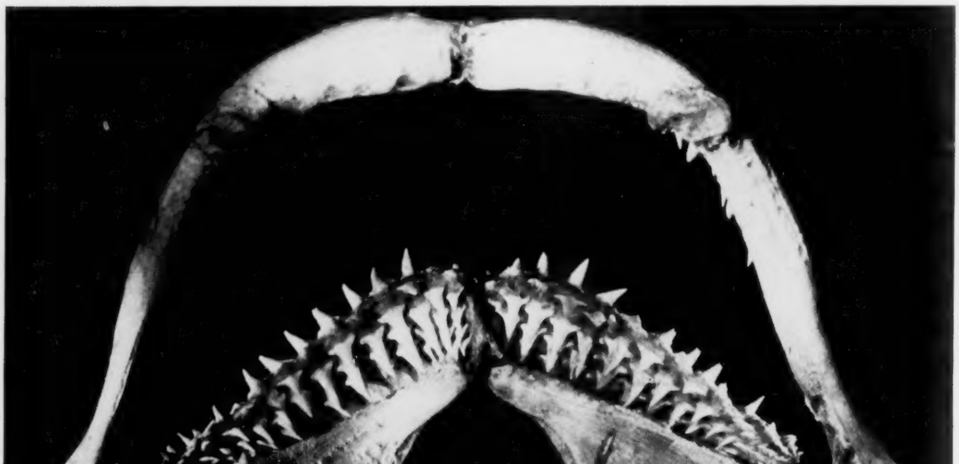
THIS SPECIES, *Dasyatis centrura,* OCCURS FROM BEAUFORT, N. C., NORTHWARD ALONG THE ATLANTIC COAST. NOTE POSITION OF THE TWO SPINES.

was found which had been driven into the "gum" of the jaw; that is, into the fold of tissue covering the rear (young, or "baby") teeth of the shark (Fig. 3). This sting had penetrated the big jaw cartilage, and the point protruded on the outside of the jaw. This shows what a heavy stroke a large ray is capable of inflicting. Other spines were found stuck in the membrane of the left lower jaw, and 5 spines in the gums and membrane covering the right lower jaw.

Some of these are seen affixed to the inner side of the lower jaw (Fig. 3). One sting, indicated by the arrow, had split the tooth bud, and from the bifurcated tooth germ two sets of half-teeth had grown. There are at least four rows of these half-teeth present. How many had been broken off in front in the course of time cannot be determined, nor can one say how long it takes a single pair to develop. But plainly this shark had lived years since the spine became embedded in its left lower jaw and since all the other spines had accumulated. Evidently it was immune.

The Sharp-nosed Shark. In 1919 Dr. R. C. Murphy, of the American Museum, captured a specimen of the sharp-nosed shark (*Scoliodon terrae-novae*) off Sanibel Island, West Coast of Florida, and sent the jaws to the Museum. In the left lower jaw was found the tip of a sting embedded in the tissues covering the jaw. If at the time of capture a hunt had been conducted for other stings in the jaws and the throat region of this shark also, there is a strong probability that such would have been found. This shark, like the others, seems immune to the poison of the sting ray.

The Tiger Shark. There is one other identified shark known to be a sting ray eater. This is the well-known tiger shark (*Galeocerdo tigrinus*) with the sickle-shaped teeth. In 1784 William Andre published a drawing (Fig. 4) showing a sting ray spine embedded in the gum of a jaw. It had split the tooth germ into halves and had done this so long ago that at least 6 pairs of half-



After Gudger, 1932

FIG. 3. A SHARK'S LOWER JAW SEEN FROM BEHIND

CEMENTED TO THE JAW CARTILAGE OF A BLACK-TIPPED SHARK ARE SOME OF THE 13 STING RAY SPINES FOUND IN THIS SPECIMEN. THE ARROW POINTS TO A STING EMBEDDED IN "GUM" CARTILAGE.

teeth had developed into full size, as the figure shows. Years must have been necessary for this.

Just 137 years later, corroboration was obtained that the tiger shark is an eater of rays. In 1921 Bell and Nichols recorded the finding of fragments of sting rays in the stomachs of two tiger sharks caught at or near Cape Lookout on the North Carolina coast. The presence of stings, if any, in the mouth parts was not noted since no dissection of the jaws was made.

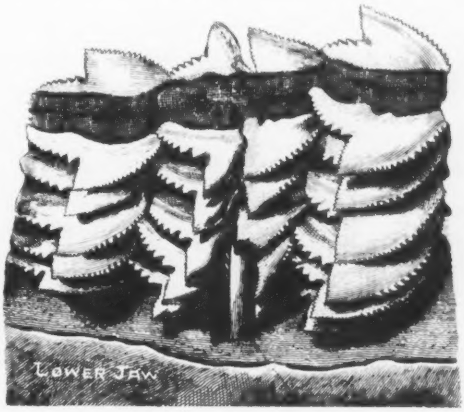
I have seen tiger sharks chasing sting rays in the waters about Key West, Fla., and there and at Dry Tortugas I have dissected a considerable number of these sharks but, being particularly interested in the reproductive organs, I unfortunately made no search for stings. However, the above citations clearly show that these tigers of the sea are feeders on rays and are seemingly impervious to the poison of their stings.

Sharks in General. Capt. W. E. Young has been connected with shark fisheries all around the world and, as an outcome of his long experience, has a large knowledge of these fishes. He has kindly communicated the following résumé of his observations on sharks feeding on rays and being stung by them:

> Sharks everywhere seem fond of rays and may be found feeding on them. These rays are all provided with from one to five sharp stingers of bone with barbs pointing backward. These stingers inflict terrible wounds on human beings, but though the ray stings the shark when it catches and eats the ray, the stings do not seem to injure the shark. The shark cuts up the ray, and swallows the parts, the tail often being included. Thus the stingers get into the stomach of the shark where I have often found them. Eventually these work out through the wall of the stomach and get into the muscles and work toward the head or the tail according as they are pointed. I have found a sting on the back under the skin and another up near the brain.

Why Are Sharks Seemingly Immune to the Sting Ray's Venom? This is the insistent question with which this article must end. And to it there is no sure answer known—at least to the writer.

The ray's sting is a strong, bony, barbed spine (Fig. 1) firmly rooted in the upper median surface of the tail (Fig. 2). Along the center of the underside of the sting is an elevated smooth rib and



After Andre, 1784

FIG. 4. A PIERCED SHARK'S JAW

A STING RAY'S SPINE IS EMBEDDED IN THE JAW OF A TIGER SHARK. LONG BEFORE THE SHARK WAS CAUGHT, THE STING HAD DIVIDED A TOOTH GERM, THUS GIVING RISE TO SIX PAIRS OF HALF-TEETH.

on each side a groove between the rib and the serrate teeth. This may be noted in the spines of Figure 1. Those spines shown in dorsal aspect have a slight groove down the center. Under the root of the spine is the poison gland, and extending backward in the lateral grooves on the ventral surface are poison-filled canals with close-set nipples opening outward near the teeth. When the sting is driven into an object, pressure is exerted on gland, canals, and nipples, and the venom is extruded through the nipples into the lacerated wound caused by the teeth of the spines.

The shark's skin is remarkably thick and tough, being made up of closely

interlaced fibers. It requires a hard-flung harpoon to penetrate the taut skin when a shark has stiffened its body. I have seen a harpoon thrown by a strong and expert harpooner rebound from the humped back of a nurse shark at the Marquesas Atoll in the Florida Keys. Likewise, it requires a sharp stroke for even a keen-pointed sting ray's spine to penetrate the thick and dense skin of a shark, which is often from one-half to three-quarters of an inch thick. And in penetrating it, much—indeed most, if not all—of the poison will be squeezed out and left on the outside of the skin or on the walls of the cut in the skin. Below the skin are the thick body muscles tightly adherent to it. These muscles seem to be much more poorly supplied with fair-sized blood vessels than the leg of a man or any other vertebrate.

But it may be asked, "How about the poison from spines found in the stomachs of sharks?" These had had the poison-gland tissues digested away, and the poison had apparently had no deleterious effect on the sharks, even in the case of the shark with 17 spines found in its stomach. However, it is well known to medical science that certain poisons which are active when injected into the human body are harmless when taken into the digestive tract. And the same is probably true of a poisonous sting and a shark.

From these facts the conclusion may be drawn that the ray's sting probably carries very little poison into the muscle masses underneath the skin of the shark. But the only way to settle the question as to whether this apparent immunity of the shark to the poisonous sting is real is to get a live ray and a live shark. Then one must anesthetize the shark after the technique used at Marineland Aquarium near Saint Augustine, Fla. This done, the skin and body wall of the shark must be laid open to expose a nerve or a blood vessel. Then if a fresh sting is driven into one of these organs, or a solution of the venom in sterile water is injected, one may expect to find whether or not the shark's apparent immunity is real. The same experiment should be done for live rays and for bony fishes. This would surely be an interesting piece of research for some student to take up at a seashore laboratory.

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THE EDUCATIONAL POLICIES COMMISSION BANISHES SCIENCE

By FRANKLIN BOBBITT
PROFESSOR EMERITUS, THE UNIVERSITY OF CHICAGO

Except for blind feelings, man's only guide in a complex world is understanding. Today he needs a vast amount of it; and that of the kind that is most reliable.

For several generations the world has been making swift advance in the ways of human living and in the discoveries, inventions, production, and distribution that make modern living possible. With bewildering speed, a simple world has become complex. Affairs that until recently could be managed by simple understandings have become so complicated as to require widened, deepened, and enlarged understandings on the part of everybody.

During the last thirty years of this rapid advance, the world has almost wrecked itself by mismanagement, unnecessary conflicts of purposes and procedures, unnecessary total wars involving the most frightful carnage in the history of the world, and unnecessary confusion of thought, bitterness, and hatred everywhere. As a result, catastrophe has laid its heavy hand on all humankind. The promise of the future is dubious.

The trouble has resulted from man's inability to find the right ways through the complexities of the modern world. It is not that men and women have degenerated; they are as honest, well meaning, and conscientious as ever. Even when wreaking the most terrible havoc, they are aiming at what they think to be commendable objectives. Mankind is sound at heart. People have no desire to destroy themselves or the foundations of their well-being.

The missing ingredient is understanding. The inability of people to see the world as it is, is the source of all their woes. And this disability is not due to native inability to understand. What men create they can, if they try, bring themselves to understand well enough to manage.

Every person, man and woman, needs the best wisdom that can be had. Since everything depends on rightness of guidance, they need the kind that gives the greatest assurance of rightness. And the best knowledge, the most reliable, the only kind that is assured and genuine, is that supported by the most carefully assembled evidence. That is *science*. The science of a thing is the best understanding of that thing that the human race to date has been able to arrive at. The science may be complete or incomplete. It may be entirely, or only partially, established. When fully established, its guidance is wholly trustworthy. Where yet incomplete or only partially established, it is still man's best understanding and therefore his best and safest guidance.

The world is not being wrecked by lack of understanding in the specialized vocations. They have science and they are rigorously obedient to that science. As a consequence, the achievement of rightness and success in the world's work is the most marvelous thing that mankind has yet accomplished. The amazing success of the specializations in finding and holding to rightness is our best proof of the power of science to guide mankind aright.

But a democracy is not operated by

the specialists nor by the wisdom of their specialties. It is managed by laymen, by all men and women, as directed by laymen's understanding. If science is to be the director of this general social management, it must be the science that is known, not by specialists, but by laymen.

The successes of the specialists have been so spectacular, our attention has been so fully focused upon them, that we have mostly overlooked the fact that the world is basically a world of laymen, operated by laymen, for the lifelong well-being of laymen. The work of the specialties is but service to laymen. A person is a specialist serving the general society for some 40 hours a week; but he is a layman, moving in the currents of general human living for some 128 hours each week. It is during this longer period of layman's activity that he is concerned with managing those more general social arrangements and procedures on which the well-being of the world depends. For his guidance during this longer period each week, he needs the greatest possible amount and the best possible quality of layman's understanding; and this is properly called *layman's science* to distinguish it from *specialist's science*.

The two kinds of science are equally sound. They differ greatly, however, in the degree of generality and in the accuracy of the details. In both kinds there are the same fundamentals; but layman's science cannot go far beyond the basic principles, whereas specialist's science goes as far as possible into everything. The specialists are the explorers who discover the science for the use of both groups. They use all of it; the laymen, only the larger fundamentals.

Since laymen are the rulers, they should be equipped with the wisdom needed by rulers. The basic task of the school, then, is to bring all normal men and women to fullness of understanding of the world which it is their combined responsibility rightly to manage. Layman's science, then, in itself and in its applications is the central and chief concern of the schools prior to the level of specialization.

This science should give men and women a sufficient understanding of all portions and phases of reality with which they are concerned, and about which they are called upon to do straight thinking. This is obviously a large order. The interdependencies of things are so great that properly to see any portion of reality one must see and understand the fundamentals of the whole of it.

We must go a little into detail. To see the world of today the layman must see its foundations in the structures and operations of the scores of kinds of atoms with their inherent forces; in the chemical structures and substances with the manifestations that attend their combinations; and he must have a full view of the further matters in the area that we call physics. He must see biological life as it has grown up, as it continues to proliferate in its endless creation, and as it operates in its millions of forms. He must see the more specific structures, functions, ways, and doings of the biological species called man—his body, its structures and functions, the propulsions that drive it, the vision that guides it, and those special biological arrangements, adjustments, and functions that we call economic life, political life, and ethical performance.

We say the layman *must* see these things. We use the term advisedly. If man is to succeed in his efforts to achieve the kind of world for which he hopes and which seems, after thousands of years of heartbreaking failure, to be at last almost within his grasp, then laymen *must* have for their guidance the kind of true and stabilized vision that

science alone can give them. If they are to succeed, there is no alternative. To make the atom bomb was a very simple thing as compared with making a humanized world of the kind that humanity wants; but without science, not in a million years could anybody have ever created that bomb. Even more certainly, without the use of science as guide to laymen, as well as to specialists, not in a million years will mankind bring forth and maintain a worthy social order. Beyond every other layman's need, science is a *must*.

All of the matters enumerated, from protons to the finest elements in the spirit of man, are part of the substance and operations of one integral universe. They are so intimately and inseparably interrelated that it is impossible to understand any of them sufficiently except as one has a sound understanding of the fundamentals of all. Each normal-minded man and woman needs to see the basic realities portrayed by chemistry, physics, geology, geography, physiography, meteorology, astronomy, biology, botany, zoology, human biology, psychology, sociology, economics, political science, and ethical science.

Our question at this point is not, Can so many sciences be taught to all normal-minded men and women? It is rather, What range of understanding do laymen *need* in order to do the straight thinking that will enable them rightly to manage their affairs of every kind in the world as it is? It can be proved that they are vitally concerned with matters in all of those areas of reality; and that they can rightly think, plan, and deal with them only as they have a layman's understanding of them. It follows that they should come to understand them as well as they can. That is all that can be expected. Whatever is done must be within the limits of the possible and practicable.

The question of what sciences laymen should be prepared to use in their daily thinking is almost impossibly confused by two things: (1) the conception that the only genuine and legitimate science is specialist's science; and (2) the usual total obliviousness of the nature, legitimacy, and imperative need of layman's science. The sneers of specialized scientists for layman's science has long been, and is yet, a withering influence. For high schools and junior colleges, they have insisted on specialist's physics or nothing, specialist's chemistry or nothing, specialist's economics or nothing, specialist's everything or nothing. The result has been increasingly, for most sciences and for most pupils, nothing. Insistence on specialist's science before the time is ripe for specialization has not only prevented the layman's science that is so sorely needed, but it has been defeating the specialist's own purposes. It has been driving science out of the schools. Had they been fostering layman's science to the full during the years of schooling prior to specialization, they would have been laying in the whole population the broad and solid foundations needed for the further refinements of the specialist. The latter's intellectual intolerance has been, and is, calamitous both to laymen and to his own supremely important work.

Understanding of things is merely a matter of seeing them—with the eyes and with what lies back of the eyes. Science is nothing more than an adequate seeing of the realities. It is in the power of laymen to see them. They can see position, form, amounts, qualities, relations, functions, behavior, forces, structures, values, genesis, and the nature and operation of the parts and subparts. Their seeing begins in infancy and is a widening and deepening thing through the years of childhood. During those early years, a wide observation and experience can and should provide sound beginnings of understanding. But it is

during the mental efflorescence of youth that the major expansion and deepening of understanding can be expected. It is from the age of fifteen to twenty or so, *the high school and junior college* period, that the full intellectual luxuriation of each youth should carry him through all the inviting avenues of what the well-awakened scientist knows to be a bewilderingly rich and diversified world.

To see the world as it is, one must go on his intellectual travels over and through that world. To see its various intellectual areas, he must find them all and travel back and forth and up and down through them all, repetitiously seeing in the concrete from different angles and under different circumstances the things that make them up. He must move among and observe the realities as a traveler in a new and magnificent region searches out and views every interesting feature.

If a traveler in a strange country is fully alive, and if he is luxuriating in all the opportunities that the region has to offer, he visits places again and again, enjoying them ever more deeply from the repeated experiences of seeing them under new and different angles of approach. Thus, through a combination of repetitiousness and variety, he matures his understanding and appreciation of everything. And just so it is with the youthful intellectual traveler in this wilderness of a world with its countless vistas of always marvelous and mysterious realities. He finds his intellectual life in a continuity of visiting over and over again all sorts of things in all sorts of ways in all portions of it. In the intellectual world, understanding is matured by a long-continuing repetitiousness in the variety that keeps it always interesting. And the same experience matures the appreciations that give it vigor and drive.

Is the hungry-minded intellectual explorer to memorize the facts, as of a textbook, as he goes along? Let us ask, Does the alert-minded traveler in a new and thrilling region ever stop to "memorize" anything? He does *not*. His seeing has the vividness that constitutes its own memorization. The impressions are burned into his consciousness so deeply and indelibly that he cannot forget them. His memories abide as a vital part of his being. If a traveler has to stop to memorize what he sees, his experiences are so pale and lifeless as not to be worth while.

And so it is with the youthful intellectual traveler through those vistas of reality that have been opened up by the explorations and discoveries of the clear-eyed men of science. If he sees the world widely, deeply, and truly, then he must see it with that vividness of intellectual experience that is the normal mental reaction to the marvels and miracles of a majestic world. If he is moving under full intellectual steam, he does not stop to memorize anything; his experiences are so vivid that they automatically become part of the very texture of his being. As he sees things again and again from countless angles, in countless relationships, in their various manifestations and operations, he matures a sound and unforgettable understanding of them.

When in a former paragraph we said that every normal person needs a layman's understanding of the areas of reality covered by a dozen sciences, we did not mean that he is to "study" and "master" those many sciences in their specialist's forms and in the usual futile academic way. To memorize the verbalities of textbooks of the usual kind is like sitting down in a dim room and memorizing Baedeker as a substitute for going on one's travels. It is both distasteful and worse than useless. A sound understanding of the world is not

acquired in that passively absorptive way.

In its relations to science, the school has two major functions: (1) to guide the growth of sound and proved understanding, as such, as it operates in all its applied forms; and (2) to perform the professional functions along with individuals, families, and community in keeping science the guide in the apprenticeship activities of youth in physical living, health care, family life, community life, association, citizenship, vocation, recreations, amateur arts, religion, emotional living, and intellectual living.

High schools and junior colleges have been performing neither of these two functions. They have not made the science vision of reality—physical, biological, mental, economic, political, ethical—the center and basic substance of their intellectual program. Their present plans do not lie in that direction. Quite the contrary—for layman's education they plan to abandon and to banish science. Let us present evidence of the drift.

The educators of the nation are banded together into two vast and powerful professional groups, the National Education Association and the American Association of School Administrators. In combination, these two associations have named a single Educational Policies Commission to determine the basic policies and plans for American education. This Commission is the voice of authority within the profession.

As the war showed signs of a new truce and a lull in the consuming holocaust, the Educational Policies Commission attempted to discharge its grave responsibility by announcing revised and improved educational policies and plans. After two years spent in assembling its best thought, it presented its conclusions for high school and junior college in *The Education of All American Youth.*

Since this volume voices the wisdom of the specialty for the educational profession, since this wisdom can emanate only from educational science, and since layman's science is the only kind of understanding that is good enough for laymen in an imperiled world, naturally we expect this document to make science the central intellectual responsibility of the school. What we find, however, quite unexpectedly, is that *science of every adequate sort is practically banished from the curriculum recommended for layman's education.*

Let a student take all the layman's science recommended specifically or by implication for high school and junior college, and he will not acquire a well-rounded and well-grounded understanding of the area covered by any one of the sciences, much less of the entire area of human concern.

The document refers casually in a few places to the use of science by students in guiding their efforts in such matters as agriculture, home economics, and health care. It is not made clear how they acquire that science originally; but one gets the impression that it is learned as unrelated fragments in the situations where it is applied. But one cannot learn the broad area of reality covered by a science in that scrappy manner.

The volume recommends that "science" be accorded one-sixth of the program for a year in grade X at age fifteen. But the Commission does not specify the study of the actual substance of any one of the sciences nor of any combination of them. This small part of one year is to be devoted to six things:

> (1) an examination of the scientific techniques used by research scientists in their explorations out on the frontiers of the sciences that are yet unknown even in their fundamentals to the pupils, who therefore are yet wholly unprepared to appreciate the subtleties of the research techniques; (2) noting how the application of portions of sciences yet unknown to the pupils have promoted human advance; (3) the

> biographies of great scientists, with special attention to the techniques that they employed in making certain spectacular discoveries in areas that are yet mostly unknown to the pupils; (4) reproducing in the laboratory a few samples of the epoch-making researches of scientists in fields yet unknown to the pupils; (5) impressing upon students, mostly by talk, that "we live in a world of natural laws, of orderly cause and effect, not a world of chance or arbitrary action"; (6) making children at the immature age of fifteen, and in one-sixth of the school time for a year, "familiar with certain fundamental principles and facts from the sciences, which, when taken together, give him a sound view of the nature of the world in which he lives."

There is not a word said about devoting any portion of the year to developing an understanding of the substance of any one of the sciences.

These things are to be done with a curriculum that is largely made by the fifteen-year-old pupils themselves, thereby forcing the teachers much of the time to superficial verbal improvisation in dealing with it. It is to be so managed that each pupil travels at his own gait, fast or slow, according to his own nature, no two of them traveling together. The pupil is to know the values of science without a prior knowledge of its substance. He is to appreciate and understand subtle scientific techniques used in remote regions of difficult research where at his age he cannot possibly go. He is to be vitally interested in numerous things without having had the experiences that alone can awaken those interests. A few fragmentary facts and principles are "to give him a sound view of the nature of the world in which he lives." These wondrous results are to be accomplished mostly by talk for an hour a day for a year at an age when he is still seven years short of the full normal expansion of his mental powers. And it is all to be done without systematic attention to any one of the major areas of layman's science, whether physical, biological, or human. It makes one wonder what he is to do with his head during the next six years.

The plan is a fantasy. It is startling in its disregard of the realities. As a matter of fact, as we have explained elsewhere, the whole document is a piece of utopian fiction, built on the plan of Bellamy's *Looking Backward,* in which reality and propagandistic imagination are subtly interwoven into a plan that is made to work beautifully as a dream, but which has about the same relation to the actual realities that Walt Disney's creations have to the animal world.

For a staggering world and a crumbling civilization, straight and honest thinking by men and women offers the only hope. Thought of that type is possible only to persons whose understandings are shaped by, and well furnished with, layman's science in its several areas. It is imperative, then, that science be the foundation and the framework of all intellectual education for that sound and honest thinking that alone can operate a complex and difficult world. It is doubly imperative that the education that produces this result be grounded in, and guided by, sane and straightforward educational science. For the purpose, this science should be organized and formulated in such a clear and direct way that everybody concerned can understand it.

In the face of such clear facts, it is nothing less than monstrous to find the organized sciences of all sorts practically excluded from the curriculum by the distinguished leaders of professional policies; and to find that instead of science as a guide to educators they give forth in this document a modernistic artist's picture of how education operates in a fictional world with the impossible perfection that can be put into fiction. If this is the best that education can do by way of organizing its guidance, then the race between education and catastrophe is already lost.

The omission of the physical and biological sciences is only a part of the Commission's failure. The program equally omits the development of an understanding of man as the world's most notable biological species, of his emotions as biological drives, of his understanding as biological guidance, and of his economic, political, humanitarian, and ethical procedures as adjustments in a stern and exacting world of never-ending struggle for an elusive security. These areas of human life are wide and complicated. Every man and woman needs to see their fundamentals with the greatest possible clearness. They need the best practicable layman's understanding of all the major human sciences. And yet the Commission does not so much as mention a single one of them, much less state their indispensability or give them adequate place in the program. They are omitted utterly. The Commission clearly rejects the principle that in a world of greatly mismanaged human affairs, only the best possible understanding, namely, science, can provide the only guidance that is good enough. To the Commission, the human sciences are not a *must*. They are not even important. Their value, if any, is so minor that they need not even be mentioned.

The Commission recognizes that human affairs are to be guided; but the guidance for which its plan would prepare is not that of science, but rather that of the shrewdness of the opportunism that is called political action. The direction of human affairs is not to be determined by that understanding that alone can find the right ways, but by the force, actuated by self-interest, that can be exerted by superior numbers, without regard to, or even knowing, what is right and just. This retreat from rationality as human guidance back to self-interest, force, and strife, brought to high operating efficiency by education, as the mode of managing human affairs would be the abandonment of the very basis of civilization.

The document recommends American history with artful emphasis, but says that it should be refocused and rewritten. It is careful not to say how it should be rewritten; but the general tenor of the volume indicates that American history is to be an instrument for strengthening the powers of persons for the strife of political action. If this is misinterpretation, it results from studied vagueness.

The Commission recommends that one-fifth of the entire high school and junior college be devoted to "Education for Civic Competence." This would be a superlative recommendation if the term "civic competence" were intended to mean wisdom and power in finding and holding to the ways, sanctioned by human science, for achieving right and justice to all. But by "competence," the Commission appears to mean power in the techniques of social conflict. In no uncertain terms, it voices the need of social understanding; but it does not even remotely mean that best understanding that we call science. If that were the meaning, it would be stated in definite terms.

The teaching profession is so much accustomed to weird and irresponsible pronouncements that it will look upon this latest piece of propagandistic fiction as but another example of the profession's habitual and expected make-believe. This negative attitude toward even its supposedly most authoritative literature gives it a kind of protective immunity. Educators will give this document such casual and momentary attention that its influence for harm will not be great. But this is only one of a never-ending series of pronouncements. Each affects the next in line, and also the professional consciousness, in some slight degree. There is thus accumulation of error and of tolerance

for error until in time it is very great, and the profession is unsuspectingly fully misled.

The profession has already been led so far astray that it scarcely sees anything amiss in this incredibly fantastic volume. It accepts it favorably for a moment as a matter of course and then goes on to the next in which there is a slight but imperceptible further turn toward the propagandist's goals. In this way, propaganda subtly and invisibly achieves its unannounced purposes. The present volume is a superb example of the power and skill with which this can be done.

A profession ruled by science, such as medicine or engineering, is not of this type. It goes forward today with breathtaking speed, but it follows the straight road laid down for it by its own technical science. As it changes its course with new discoveries, its deviations are always toward the more perfected truth and never away from it. It views the ways of propaganda as the ways of charlatanry. And such adult professions never use irresponsible utopian fiction as their crafty method of giving forth their science to their members. They would view it as a method of incredible juvenility, a mere toying with the matters of life and death. They know that the responsible adult mind does not operate in that way.

TO THE NEW PHYSICS

Now we who thought we lived on firmest earth
Find that we live with song, nothing but song:
From the ninth interval that is our birth
To the heart's full chant, to music we belong:
Close harmony proceeds where no throats are;
Not only trees are tongued, but mould and dew,
And music issues from the morning star
As surely now as when the heavens were new.

A flower unfolded is a mouth achieved,
Its scent a song; the many-throated rain
Marks the crescendo of a psalm that lived
In humming clouds, muted in mist again;
While the incessant spirals of our prayers
Build for the high heavens their only stairs.

A. E. Johnson

SCIENCE AND NATIONAL POLICY*

By KARL T. COMPTON

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THAT our national security, health, and prosperity depend to a great extent on science for their maintenance and their future improvement, no informed person would deny. The great drafts which we are making upon our natural resources, the demands of labor for a better standard of living, the requirements of industry for markets and profits, and international competition all pose problems among whose essential requirements for long term solution are vigorous advance of scientific knowledge and equally vigorous application of this knowledge for useful purposes.

The subject "Science and National Policy" therefore deals with one of our important national problems. I can only hope to paint the picture with a few broad strokes and to discuss certain specific measures now before Congress on which wise action is needed promptly.

Historically, our federal government has concerned itself with science in two directions: first, through its permanent scientific bureaus; and, second, through its calls for temporary help in times of emergency.

Within the framework of the federal government there are about forty bureaus of more or less scientific character. Generally speaking, these are service bureaus which employ scientific methods to supply the public with types of information or help which private enterprise is not well fitted to provide. The Bureau of Standards, the Weather Bureau, the Geological Survey, the Bureau of Mines, and various bureaus in the Department of Agriculture are examples. Their services to the public are essential and should be maintained in a high state of efficiency.

In times of great emergency the federal government has called upon the creative scientists of the country generally for help, and this help has always been given wholeheartedly, to the very great advantage of the country. In 1863, at the time of the Civil War, the National Academy of Sciences was established by Act of Congress and approved by President Lincoln. This Act specified that "the Academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art. . . ."

Again, when war clouds hung low over the world in 1916, President Wilson by executive order requested the National Academy of Sciences to establish the National Research Council as a measure of national preparedness.

Again in 1940, when threat of war hovered on our horizon, President Roosevelt established the National Defense Research Committee which, one year later, was enlarged by the establishment of the Office of Scientific Research and Development. And during the darkest days of this World War II, when Japan had cut our lifelines to natural rubber, the President appointed the Rubber Survey Committee which organized a group of scientists, engineers, and businessmen under the statesmanlike leadership of Bernard M. Baruch to establish a program for meeting this technological crisis.

In every one of these cases the scientists of the country responded immediately to render national service with

* An address delivered April 25, 1946, before the American Newspaper Publishers Association, New York, N. Y.

outstanding effectiveness. The recent success of the rubber program and the wartime achievements of the scientists in developing new medicines or new weapons, culminating with the atomic bomb, are too freshly in mind to require further comment. They shortened the war, saved billions of dollars and millions of lives, and were one of the essential elements in victory.

One thing which does require comment, however, is this peculiar fact: Why has it been only in times of desperate emergency that the government has called upon the scientists of the country in any significant way to perform service, and why is it only at these times that the government has provided the funds necessary to implement any scientific programs of substantial character?

President Roosevelt had this question constructively in mind when he wrote in November 1944 to Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, requesting recommendations for a program to aid research activities by public and private organizations, to continue the war of science against disease, and to discover and develop scientific talent in American youth, so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war. Dr. Bush had this in mind in his reply to the President when he said:

> New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war, we can create a fuller and more fruitful employment, and a fuller and more fruitful life.

But let me approach this matter from another angle.

I fear that the American public generally has a false sense of security through a naive belief in the superiority of American science over that in other countries. This belief undoubtedly comes about naturally from the fact that American industry has shown unparalleled initiative, drive, and skill in pouncing upon the practical applications which can be built upon scientific discoveries made any place in the world and turning out manufactured products of superior quality and in unequalled quantities. American advertising, however, is not accustomed to admit that such and such of its developments have sprung from a scientific discovery in Holland, or in Russia, or in Germany. The actual fact is that American science is strong and its scientists are able, but America has no monopoly, nor does it have even a majority position, in the record of scientific discovery.

Along this line I quote three paragraphs from the first issue of the new McGraw-Hill publication *Science Illustrated.*

> But our wartime victories in applied science were based largely on basic European research. The fission of uranium was first developed in Germany. Bloodbanks originated in the Soviet Union. The discovery of penicillin earned Nobel prizes for three British subjects.
>
> It is a matter of prime concern that our own basic research has lagged so far behind our industrial capacity to absorb technological developments. The extent to which our industrial machine has lived off foreign basic knowledge is shown by the distribution of Nobel prizes. [The article then goes on to show that only 18 out of the total of 131 Nobel prizes which have been awarded in physics, chemistry, medicine, and physiology, have gone to scientists of the U. S.]
>
> This situation is likely to grow worse unless definite steps are taken soon. Available figures show that only one-seventh of the national research budget was going for basic research before the war. Now as a result of war-interrupted educations of thousands of youth, the nation faces a deficit of scientifically trained personnel.

Actually, until about the time of the first World War, the United States was distinctly a third- or fourth-rate nation so far as science, either in scholarship or in creative research, was concerned.

Since about 1920 the United States has advanced with great rapidity, and by the beginning of World War II it had achieved a position roughly abreast of the other more advanced nations. No informed scientist, however, can say that it has ever achieved a superior position.

In my judgment the rapid advance of creative science in America since about 1920 was principally due to two causes. One of these was the increased public awareness of the value and power of science, arising from the demonstrations of its effectiveness which were made during World War I. American chemical industry, for instance, practically dates from this period. More able young men were drawn into scientific careers, and there was greater public support of scientific research.

The other great influence, in my judgment, was the program of postdoctoral National Research fellowships, which were financed by the Rockefeller Foundation and administered by the National Research Council. The Rockefeller Foundation realized that the war had interrupted the education of scientists, and that there was a deficit to be made up. Furthermore, this Foundation has always been intensely interested in the advancement of medical knowledge and art, and it had the foresight to realize that the most fundamental advances in medicine in the long-term future were likely to be based upon new discoveries in physics, chemistry, and biology. As a result, a majority of the top scientists in America at the present time and a majority of those who took the leading roles in our recent scientific war effort were scientists who had been given this opportunity for special advanced experience in research by these National Research fellowships.

From these facts we can certainly learn a lesson for our guidance today!

Now let me lead up to the subject of national policy by still a third route, the financial one. If the scientific experience in this war proved any one thing, it proved that the teamwork of groups of competent scientists, supported by adequate technical assistance and all the equipment which they needed, could accomplish more than even the scientists themselves had dared dream. But such research programs cost money.

Industry can and will carry part of the load. But its interests are largely limited to the business possibilities of practical applications. For this and several other convincing reasons, we must, as in the past, look principally to the educational institutions to produce new scientific knowledge.

But in the past fifteen years or so the income from endowment funds of these institutions has seriously shrunk, and future prospects for large gifts and the growth of a new generation of great philanthropists are not promising. I need not expand upon this sad story.

We seem, therefore, to be faced with a very definite dilemma. The value of a vigorous program in creative science is clear. National policy requires it in the public interest. The institutions where the work can best be carried on cannot from private sources finance the whole load. This is true in all scientific fields and, above all, in the new field of nuclear science and atomic energy. Apparently the only possible answer to this dilemma is an adequate program of federal support of fundamental research.

It is such a program that ex-President Hoover sought unsuccessfully to finance by private gifts through the National Academy of Sciences while he was Secretary of Commerce. It is the same program, financed with federal funds, which was advocated by President Roosevelt, and now by President Truman, and for which bills have been introduced by forward-looking members of the Congress. It is a plan which has been followed for some years with considerable success in

Great Britain. It is a plan which is being followed on an enormous scale in the Soviet Union, where, for example, there was a strongly supported institute of nuclear science long before our own federal government gave a thought to atomic energy.

The time seems ripe for favorable action on the two great scientific projects now under consideration by our Congress: the establishment of a National Science Foundation and the establishment of an Atomic Energy Commission, both provided with adequate funds for investment in the security and prosperity of the United States. Having in mind the factors which I have already outlined and knowing rather well the conditions essential to efficient and successful scientific research (which differ in some important respects from running a railroad, or a factory, or a governmental bureau), I urge that we lend our full support to the following program of national policy in science:

1. Pass legislation to establish the National Science Foundation and to establish the Atomic Energy Commission.

2. See to it that this legislation is wisely drafted, but do not let desire for perfection unduly delay its passage. Minor defects can be corrected later as experience accumulates.

3. To the greatest extent possible, free the legislation from specific controls or restrictions; define objectives rather than specify rules for achieving them.

4. Place the control of the program in the hands of men who are competent, fair minded, concerned with its various major aspects, and experienced in the ways of science; and trust such men as patriotic citizens to handle the program in the public interest.

This scientific program is a matter of general interest to every element of the public. There is no profession or class of citizen who will not benefit from it. There is nothing in it of a political character. Are we not therefore justified in expecting that forward-looking statesmanship will enact the legislation, that patriotic citizenship will administer it wisely, and that the oncoming generations of scientists will carry it forward with high success to the benefit of all?

ON THE MATHEMATICS OF COMMITTEES, BOARDS, AND PANELS*

By BRUCE S. OLD
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THE present is considered to be a most appropriate time to study analytically, with a view toward improving, the efficiency of functioning of committees, boards, and panels in general. Two reasons supporting this stand are:

(1) The prosecution of scientific work during World War II was largely in the hands of committees, boards, and panels (*miserabile horribileque dictu!*).

(2) The security regulations still in operation, such as the Espionage Act, prevent the publishing of interesting treatises and force technical journals to accept almost anything.

The three items under consideration can be defined briefly in the following manner:

(1) *Committee.* A body of persons appointed to consider, investigate, or take action upon, and usually to report concerning some matter.

(2) *Board.* A council convened for business. (There is absolutely no authenticity to the definition "long, narrow, and wooden" sometimes applied.)

(3) *Panel.* A list or group of persons appointed for some services.

It is immediately apparent from these definitions that committees, boards, and panels are similar in that all are groups of one or more persons formed *to accomplish work.* Thus they will be treated simultaneously in this paper.

There are numerous methods of expressing mathematically the objective of committees, boards, and panels: namely, to perform work. The most commonly applied formulae are the following:

(1) The utilization of the familiar time, force, and distance relationship where the object is to maximize the expression

$$\text{ComBulPac} = \frac{fd}{t}$$

in which ComBulPac = code name for power output of committees, boards, and panels, f = force, d = distance, and t = time.

This equation was the origin in 1812 of the expression "a powerful committee."

(2) A second and very appropriate method is the use of the gas law as a basis for the work expression. Here the attempt is made to maximize final minus initial gas volume:

$$\text{ComBulPac} = {}_{v_1}^{v_2}\int p\,dv$$

in which p = pressure and v = volume.

It is held by experts that Gay-Lussac first evolved from this relationship the phrase "a high-pressure committee." On the other hand, there is no foundation for the rumor that the current slang phrase, "the committee is cooking with gas," was derived from this equation.

(3) Another method which is very useful under certain circumstances is

$$\text{ComBulPac} = Le$$

in which $L = Fr$, F = force, r = radius, and e = angle.

This, the reader will recognize, is the well-known "revolving committee."

* The able assistance of the members of the old staff of the Office of the Coordinator of Research and Development and the Office of Research and Inventions of the Navy Department and the assistance in critical review by the Applied Mathematics Panel of the NDRC are greatly appreciated.

Data were generously supplied from many sources. These, naturally, are still confidential so that no actual numbers could be used in this paper.

(4) A fourth method of setting down the work expression is becoming very common since the importance of air power has been realized:

$$\text{ComBulPac} = M(V) - C_D \frac{\rho A V^2}{2}$$

in which M = mass flow, V = velocity, C_D = drag coefficient, ρ = density, and A = area.

Recognizable immediately, here is the "committee with drag." (Drag is high for certain simple bodies.)

(5) A fifth method of calculating output has been evolved during World War II. This is to express the output for the widely used "joint" committee:

$$M = \frac{\gamma \sum Y^2}{y}$$

in which M = resistance to moment of a group of rivets in a riveted joint, γ = total allowable stress per rivet (or committee member), $\sum Y^2$ = sum of squares of distances from center of gravity of the group of rivets, and y = distance of outermost rivet from center of gravity of the group.

The reader will note that, although elastic bending under stress of great magnitude occurs, no work is accomplished by the joint committee.

In order to determine which of the five equations best expressed the output obtained, the performance since December 1941 of a large number of committees was analyzed. Very poor correlations were found between the actual and theoretical calculated work outputs. These results are plotted in Figure 1 for all five methods of calculation.

This poor correlation showing the actual output of wise decisions, good reports, and constructive accomplishments per year, always far below theoretical, led to the decision that a much more thorough analysis than had been made heretofore would have to be undertaken. The importance of this study to the war effort was such that an overriding priority was assigned. (By a fortunate error, the file clerk placed this problem on the top of the growing pile of overriding priority projects so that it took an over-overriding precedence and was completed only seven months behind schedule.)

Analysis. The most logical mathematical approach to the problem of calculating accurately the output of committees appeared to be the application of the method of multiple correlation. This tedious procedure was therefore used. Certain machines, such as the one at Harvard College, were of invaluable assistance in carrying out the calculations.

It was decided that the work output must be such that

$$W_a = E_2 W_t$$

where W_a = actual work, W_t = theoretical work, and E_2 = actual efficiency of the committee.

Since it was believed that W_t could be calculated quite accurately, it became obvious that a study of the factors affecting the efficiency of operation of committees, boards, and panels leading toward an accurate calculation of the efficiency, E_2, was the key to the problem.

Therefore, as a first step an equation was written in the following form:

$$E_1 = f(n)\, f(i)\, f(c)\, f(hs)\, f(t)\, E \quad (1)$$

in which E = theoretical committee efficiency, E_1 = calculated committee effi-

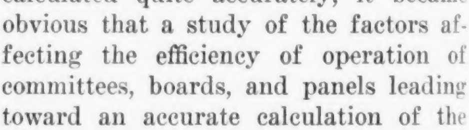

FIG. 1. WORK OF COMMITTEES

ciency, $f(n)$ = function of number of committee members, $f(i)$ = function of intelligence of committee members, $f(c)$ = function of type of committee chairman, $f(hs)$ = function of type of hecklers and saboteurs on committee, and $f(m)$ = function of the miscellaneous element; and where the calculated committee efficiency is expressed as a function of various parameters times the theoretical efficiency. The object is to arrive at the proper values of the various parameters so that

$$E_1 = E_2$$

where E_1 is the calculated and E_2 the actual efficiency.

A thorough study of the parameters in equation (1) will now be undertaken.

Many examples show that the number of men on a committee, $f(n)$, affects very materially the work accomplished. These data are plotted in Figure 2. It is apparent that it is best in many cases to have the membership limited to one, and membership of over five is usually fatal.

One striking thing to note about Figure 2 is the large scatter of points for any one value of the number of committee members. This was interpreted to mean that other parameters were affecting the data, such as the intelligence, etc., of the individual members. That this is actually the case will now be shown.

A large number of observations have been made of the effect on output of the

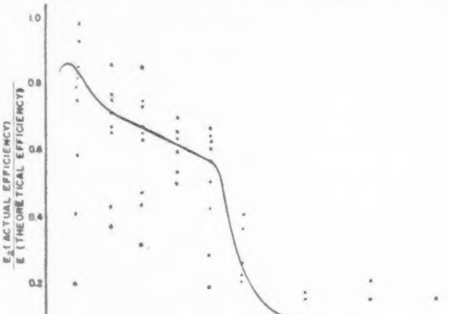

FIG. 2. EFFICIENCY VS. NUMBERS

intelligence, $f(i)$, of individual committee members. This matter of abilities of personnel on committees can usually be reduced to the following simple terms of division:

(1) Working-level personnel who know the details of the subject under consideration.

(2) Policy-level personnel who know no details of the subject under consideration.

Thus in forming a committee, one is confronted with the decision as to whether he wishes the membership to be composed of working- or policy-level personnel. The war has presented a unique opportunity for arriving at a proper answer to this question. It so happens that the rank of a military man is directly related to the degree to which he is a policy man, thus allowing an absolute measure to be applied. Pursuing this promising lead, a remarkably fine set of data was collected, thus allowing the establishment, as follows, of perhaps the most fundamental law discovered in this paper:

$$I = \frac{E}{R} \quad \text{(Old's Law)}$$

in which I = intelligence in any given subject, R = rank of individual, and E = a constant of very small magnitude of the order of $1/c$, where c is the velocity of light. This indicates that E has the dimensions of a wave "slowness."

As can readily be seen from Figure 3, there is little deviation from the law except at the extremities. (In this regard it maintains its similarity to Ohm's Law, $I = E/R$.) It follows that it is a simple matter to deduce the fact that if one desires to form a committee with high efficiency of work output, it is essential to select working-level personnel. Data supporting this statement are plotted in Figure 4. As would be expected, there are individual exceptions which appear as points off the curve, and those will now be analyzed.

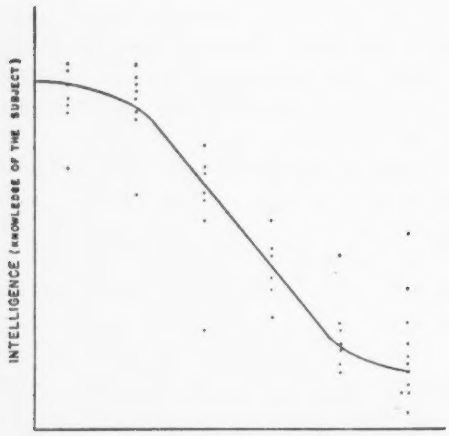

FIG. 3. INTELLIGENCE VS. RANK

One factor which affects strongly the ability of even an intelligent committee to do useful work is the capability of the chairman of the committee ($f(c)$). Let us type the characteristics of committee chairmen in the following manner:

(A) A really capable man who knows the subject, has well-prepared agenda distributed before the meeting, skillfully keeps people on the subject (but not to the extent that he does not allow both sides of questions to be thoroughly exposed), requires that action be taken on agreements reached, follows up on such actions, makes efficient use of the method of task assignment to subcommittees, provides for periodic needling of the committee by outside experts, requires written comment on reports circulated to members, insists on a minimum of six committee meetings per year, and employs an efficient secretariat.

(B) A man similar to Type A in every respect except that he is too nice a fellow to interrupt ramblers, particularly if they happen to occupy a higher position or are older than he.

(C) The man who is one of the leaders in the field under consideration but who uses the committee merely as an instrument to second his ideas. In cases where questionable ideas have to be forced through, he lines up his votes beforehand or rudely interrupts all opposition.

(D) The chairman who is obviously too important for the committee. He sends a deputy to run the meetings with instructions to hold off on any really important decisions until he can find time to attend and whip things into shape.

(E) The chairman who opens the meeting by frowning slightly and saying: "Now, er, ah, let's see. Heh, hrrmphh, ah. Who called this meeting? I mean, what are we here for today?"

The strong effect of the type of chairman, $f(c)$, on the efficiency of a committee is shown in Figure 5.

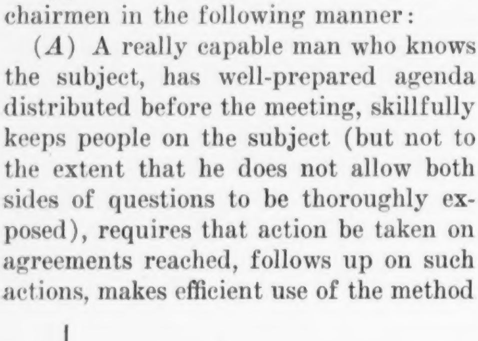

FIG. 4. EFFICIENCY VS. INTELLIGENCE

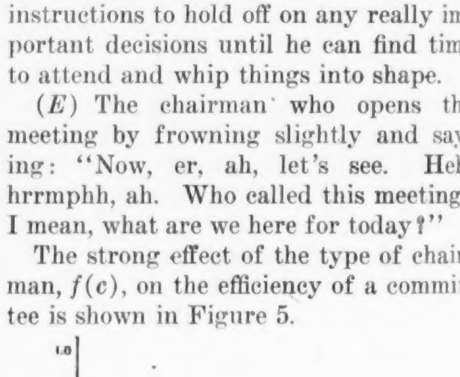

FIG. 5. TYPE OF CHAIRMAN

There are some conditions which can ruin the efficiency of a committee even though it may have intelligent members and a competent chairman. The most serious of these is the heckler-saboteur function, $f(hs)$. The main types of heckler-saboteurs, many of which are well known, are as follows:

(*A*) The normal man. (All *Homo sapiens* have some faults.)

(*B*) The jolly fellow who is always 22 minutes late and then holds up proceedings 7 more minutes telling (off the record) his latest joke. Although he never does any committee work between meetings, he is such a good egg he never fails to get reappointed.

(*C*) The man with an elephantine memory to whom all ideas are old and who can still quote all the reasons used to turn any one of them down 11 or 12 years ago. No chance for viewing anything in a new light is given—the mere fact that he had heard of it before is sufficient reason in his mind to vote against any idea.

(*D*) The man who is against initiating any work, because, since there is a shortage of scientific manpower, any new project undertaken is bound to interfere with the progress of all existing projects (particularly two of his pet programs).

(*E*) The poor fellow sent to represent his boss who has instructed him in such a manner that all he can do is sit there and say, "I don't know," or "I have no authority to speak for my agency."

(*F*) The policy man who is afraid the rest of the committee is trying to take away some of his power and authority. Thus, he views each question not from the standpoint of whether it is the best thing to do, but whether the answer given might possibly be misinterpreted by anyone as permission for someone to infringe upon his cognizant empire.

(*G*) The man who is on the defensive. He suspects the committee has been formed just to change (Note: for the better) his method of doing something. His actions are almost bound to hew to the following pattern:

(1) Announces that his office carefully considered this idea, which is really not basically a new one, about a year ago, and decided to turn it down in favor of the design now in use.

(2) When (1) is attacked successfully, states rather emphatically that this new design is just the idea of some long-haired, impractical professor who doesn't understand the wear and tear on this gear out in operation.

(3) When (2) is successfully countered by the opposition, says proudly that the Fleet has never complained about the present equipment (but fails to say the fellows who should complain are all dead, or too busy, or don't know about the new idea).

(4) When (3) is slipping, reads a policy directive issued by the Chief of Naval Operations in 1924 which makes it somewhat doubtful whether regulations allow informal committees like this cognizance to recommend a change.

(5) When (4) is overruled, says confidently that the training program is so far advanced no design change could be tolerated.

(6) When (5) fails, pulls his ace and shouts that ship deliveries are being held up now because the production schedule on this equipment is way off, and no design change could possibly be accepted even if it were an improvement. After all, there is (or was) a war going on!

(7) If (6) fails and enough rope is given, goes all the way out and openly hangs himself by sneering that of course if you want to make this equipment so perfect the enlisted man using it doesn't even have to exercise any judgment (Note: such as doing double integrations in his head), he won't take the responsi-

bility for your having ruined the man by making it unnecessary for him to use his skill gained through supertraining.

The effect of the $f(hs)$ factor is plotted in Figure 6. The gain that can be made

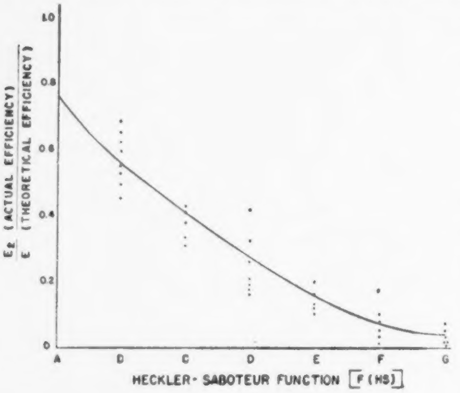

FIG. 6. TYPE OF SABOTEUR

by selecting A type committee members is very apparent.

Finally, there are several factors that can best be termed "miscellaneous" which upon occasion seriously affect committee efficiency. Among these are such things as the temperature of the conference room, the degree of comfort of the meeting chairs, the size of lunch served, the amount of time wasted during the meeting in arranging for train and hotel reservations, and whether a quorum of committee members happened to get together the night before the meeting and settle all the expected controversies of the morrow in the bar. The latter practice is recommended by many competent committee chairmen but requires more research before definite conclusions can be reached.

From the nature of the miscellaneous factor, $f(m)$, it is apparent that this parameter must be estimated for each special case.

Results. Using a slightly modified standard form of multiple correlation calculation to evolve the proper parameters for the several variables, a variance of 0.3 was obtained for correlation between calculated and actual committee efficiencies. Snedecor's test of significance showed this multiple correlation to be almost significant.

Employing corrected calculated efficiencies, the actual (W_a) and calculated (E_2W_t) committee work outputs have been replotted in Figure 7. It will be noted that, while a distinct improvement has been made over the original data plotted in Figure 1, the actual work output of committees is still disappointingly far below theoretical.

FIG. 7. WORK RECALCULATED

Conclusions. The lack of correlation achieved in this paper is regretted. It may be that the choice of parameters was completely unsound. One point which particularly baffles the author is the peaking of the efficiency of output of a committee versus number of committee members (Figure 2) at seven-tenths of a person. Obviously one must conclude that either further research is required or that people are no damned good.

FREEDOM IS FITNESS

By ARCHIE J. BAHM
DEPARTMENT OF PHILOSOPHY, UNIVERSITY OF DENVER

AN INDIVIDUAL is free whenever he is able to do what he wants to do. There are as many kinds of unfreedom as there are kinds of things which make it impossible to do what one wants to do. Some of these result from causes outside of self; others result from internal causes. For example, if I wish to climb a tower but lack sufficient energy or desire, then I am unfree to do so.

Feelings of freedom—to be distinguished from real freedom—arise most commonly in connection with awareness of external limitations. To feel self-determined is to feel free. Self-determination arises out of a feeling that the causes of action are internal. Because we conceive ourselves differently at different times, what it takes to make us feel free will likewise differ from time to time. Since the stature of a man depends upon the number and kinds of things with which he feels identified, the amount of freedom he feels will be determined by the number and kinds of causes of his action that seem to be contained within himself. The larger the range of identification, the freer he feels. If only external restraints, or the things to which he feels opposed, cause the feeling of unfreedom, then any shift in feeling from opposition to identification involves a shift in feeling from unfreedom to freedom.

Real freedom, as compared to feelings of freedom, has to do with limitations to action, regardless of whether there is awareness of these limitations. Freedom to be or to do exists only if conditions permit.

For terminological convenience causes conceived as internal are spoken of as "capacities," and those conceived as external as "opportunities." A man is *able* to do only what he has capacity and opportunity to do. Thus "capacities" and "opportunities" together make up "abilities." If real freedom means "being able to do what one wants to do," then ability to do depends upon whether both required capacity and opportunity are present.

Freedom involves fitness, and is measured by the extent to which capacities and opportunities are fitted to each other. It also involves functional efficiency. Two persons, one with great capacity and equally great opportunity and one with small capacity and equally small opportunity are, in a sense, equally free. Concomitant increase in capacity and opportunity makes one freer—quantitatively. Increase in fitness of capacities and opportunities to each other makes one freer—qualitatively.

Although real freedom rests upon relative fitness of opportunities and capacities, regardless of whether there is awareness, freedom may be affected by awareness. Insofar as action cannot take place without awareness, such awareness, or degree of awareness, is a part of capacity. Or, awareness may serve also as opportunity, for where there is no awareness, there is no appreciation of opportunity.

An individual may have abilities of which he is aware, but which he has no desire to use. Insofar as he cannot act without desiring to act, such desire is part of his capacity or opportunity to act. Increasing interest in doing what one is capable of doing actually makes one more free, and increasing indifference to one's abilities decreases freedom.

Conflict of desires affects freedom; and the more intense the conflict, the less freedom. Each opportunity to choose

between desired alternatives presents a conflict of desires, and until a decision is reached a state of unfreedom exists. What relief is felt when an important decision has been reached! It might be supposed that the more choices there are, the more decisions to be made, the more freedom exists. Actually the very opposite is true. "Freedom *from* choice" is as much a kind of real freedom as "freedom *of* choice." Real freedom, then, consists in fitness of capacities, or internally caused abilities, and opportunities, or externally caused abilities.

Feelings of unfreedom always occur when opportunities seem to be limited by external causes, but these change to feelings of freedom whenever feelings of identification with these causes arise. Such changes normally happen automatically without attention to, or awareness of, them. Suggestion and habit play a large part. However, one can deliberately seek such change.

FREEDOM FOR WHAT?

A man alone with nature in the raw
Is free as are the beasts of field and wood
Not one whit more nor less, and life is good
To him alone who knows and keeps its law.

Seek not for freedom in uncultured hordes.
The bonds of custom weave a fearful net
That rigid bounds to innovation set
Nor brook advance where status quo is lord.

The academic voice was scarcely heard
In frontier fights for freedom of the mind.
Defender of the faith and state, it whined
To gain prestige, and in their thoughts concurred.

The grant to him who seeks where truth applies
Is not a right primeval but has grown
From test pragmatic and from value shown.
On this our future social wealth relies.

When counter to the mass a thinker stands
And points to truth, then should his peers defend
By show of worth 'till opposition end,
And reasoned aquiescence raise its hands,

For freedom gains momentum if and where
Directed to some other goal than self
It adds to life stability and health
Removing ignorance and groundless fear.

JOHN G. SINCLAIR, 1945

SCIENCE AS THE COMMON GROUND FOR RELATIONS BETWEEN NATIONS[1]

By M. PIJOAN[2] and F. TROWBRIDGE VOM BAUR[3]

DURING the past twenty years there have been remarkable changes in the relationship of political structures to each other. Political negotiation in the old sense can be considered as outdated when expressed in terms of subtle argument, hidden motives, or in settlement through procrastination. Compromise, somewhat effective as yet, will, in a short period of years, become rarer; political schemes can be seen through, even though "the guarded phrase" results in the maintenance of friendly relations. Today there are no schemes which cannot be understood; what is important is the method at arriving at the truth. President Truman, commenting at San Francisco, stated:

> The world has learned again that nations, like individuals, must know the truth if they would be free—must read and hear the truth, learn and teach the truth. We must set up an effective agency for constant and thorough interchange of thought and ideas. For there lies the road to a better and more tolerant understanding among nations and among peoples.

This statement implies the use of the scientific method and not "impressions gained" or flowery statements of a superficial character. It emphasizes the necessity for a general respect for the truth throughout the world as the foundation for better relations between nations, and in the recognition of truth the role of science and professional people is paramount.

The last war has demonstrated perfectly clearly that diplomacy based on facts is a nation's first line of defense. Only when diplomacy breaks down does war result. Hence the importance of good diplomacy, that is, of maintaining good general relations between nations, can scarcely be overestimated. With the development of atomic energy it seems obvious that if civilization is to survive it can do so only on a basis of maintenance of good relations between nations which will be founded on genuine, not superficial, understanding and respect between their peoples.

The traditional concept of diplomacy has been that of negotiation and personal relationship between two high-ranking officials of separate governments. These two might be close personal friends, yet their governments and peoples might be hostile. Or the two diplomats might not get on well personally, though the feeling between their governments and peoples might otherwise be friendly. Under this traditional concept, much depends upon a single man for good relations with a foreign country. The importance of selecting able men in the Foreign Service of the United States to serve as ambassadors and diplomatic officers and of paying them adequately will be in the future more important than ever, for they have the prime responsibility of maintaining good relations with foreign countries.

We are now faced with the compelling necessity of reaching and maintaining an understanding, a mutual respect and appreciation between the peoples of different nations from which an enlightened public opinion can arise that will tend to prevent a sadistic madman from reaching a position of power in some country,

[1] The opinions and views of this article are those of the authors and not necessarily those of the Navy Department or Office of Inter-American Affairs.

[2] Lt. Cmdr. Marine Corps, United States Naval Reserve, Naval Medical Research Institute, Bethesda, Md.

[3] Formerly Regional Counsel, Office of Inter-American Affairs, Guatemala City.

with the plan and the real chance of destroying the rest of civilization. Such an enlightened public opinion can provide the substantial bulwark for diplomacy which in the future will be indispensable.

Hence today we see the beginning of international relations based on the collection of data pertinent to a case; of peoples calling on peoples for understanding and common action through the efforts of enlightened agents using scientific methods. The essentially simple solution of delegating problems to experts in the subject matter has finally been reached.

A NOTABLE example of the use of experts in adjusting difficulties between two democracies having common aspirations and problems is the recent settlement of the Mexican oil expropriation difficulty. (The following discussion is taken in substance from H. S. Person's *Mexican Oil,* Harper and Bros., 1942.) It should be observed that this effort to settle the Mexican oil problem by referring it to experts whose agreement, if reached, should be definitive as between the two governments was not intended by either government to establish a precedent either in respect of method or of findings. The final item of the agreement between the two governments states specifically that

> nothing contained in this note shall be regarded as a precedent or be invoked by either of the two governments in the settlement between them, of any future difficulty, conflict, controversy or arbitration. The action herein provided for is solely to this case, and motivated solely by the character of the problem itself.

However, as an example it has significance not confined to the two nations that were parties to the settlement.

On March 18, 1938, the Mexican government, for well-known reasons, expropriated the oil properties owned by certain corporations that were nationals of the United States of America. There followed four years of attacks on the Mexican government by the expropriated companies, who demanded that the properties should be restored, and of firm and courteous "diplomatic" exchanges between the two governments involved concerning the indemnities to be paid and the conditions of payment. Eventually these governments made an agreement dated November 19, 1941, to the effect that settlement of the amount of the indemnity should be left to experts, one representing each government; that any agreement reached by them should be final insofar as the two governments were concerned and that if agreement were not reached by April 19, 1942, the matter would automatically be restored to conventional "diplomatic" negotiation.

The expert appointed by Mexico was the undersecretary of the Department of National Economy, an engineer, Manuel J. Zevada. The expert appointed by the United States was Morris L. Cooke, consulting engineer, of Philadelphia. Each of these experts assembled a staff of specialists for the appraisal and other purposes, all leading to the agreement on the amount of the indemnity announced April 17, 1942. This then was an efficient and effective method of arriving at an agreement in a short period of time.

Formally, on the face of the assignment, the problem was one of simple evaluation—of arriving at a value for purpose of indemnification through business-engineering methods of appraisal and by precedents validated, in the United States at least, by decades of court decisions. But in reality the problem was even greater with respect to the value of the oil properties. There is no such thing as an absolute value since there are many relative values, and in context it means as many kinds of value as there may be purposes of valuation. Thus what appears to be a conventional

business-engineering appraisal was complicated by the need of harmony between experts and the ideologies of two nations. There could be no agreement in measurement without harmony. In this respect the scientific common ground was indispensable and was undoubtedly the main factor in achieving harmony and agreement.

The main problem was one of harmonizing two great social forces, one Mexican, the other based on Anglo-Saxon traditions, institutions, and laws. Each had a different origin and development. Settlement of the problem of indemnification for expropriated oil properties became a joint experience on the part of two peoples in harmonizing historic forces with present-day scientific knowledge. The scientific approach, being essentially one of tolerance, sympathy, fairness, and a search for the truth, was the common meeting ground which was primarily responsible for reaching a satisfactory solution.

Solving international problems through the scientific method is something relatively new. The people of the United States, for instance, may well recall episodes of a very different character such as the treatment of the loyalists during the War for Independence; despoliation of Indian tribes; threats of force to determine state boundaries; seizure by force of lands of neighboring peoples; slavery, civil war, and emancipation without representation. This list of illustrative items could be substantially increased. The people of Mexico also can find in their history a corresponding list of incidents indicative of an adolescent democracy finding its place among older nations.

There is no better way in any specific situation involving misunderstanding and irritation among nations than to approach the problem with an understanding of the cultural and other social forces that have contributed to the problem and its technical aspects and with humility and recollection of past delinquencies within one's own nation. This is essentially the scientific approach. The settlement of the oil expropriations by scientific cooperation between Zevada and Cooke within a period of a few months is illustrative of its value.

HERE, too, the Cooperative Program method evolved by The Institute of Inter-American Affairs of our government and the other American republics has proven of value. (The Institute of Inter-American Affairs is a government corporation organized and controlled by the Office of Inter-American Affairs. Cooperative Health and Sanitation and Food Supply Programs are carried out pursuant to agreements between The Institute of Inter-American Affairs and the various Latin-American Republics. A similar government corporation, the Inter-American Educational Foundation, Inc., has entered into similar agreements with the other American republics for the carrying out of Cooperative Educational Programs.) Traditional diplomacy is primarily negotiation between two men; a Cooperative Program is a form of concrete activity between the professional people of two countries, based on science as the common ground, and with the common objective of developing a subject impersonally for the common benefit of the peoples of the two countries.

In the Cooperative Health and Sanitation Programs United States doctors, sanitary engineers, and nurses work directly with the doctors, sanitary engineers, and nurses of other American republics, determining the best methods for the improvement of health and sanitary conditions in the particular circumstances. Doctors, sanitary engineers, and nurses from these countries come to the United States for study and training,

and they necessarily return with a personal, first-hand knowledge and appreciation of conditions and people in the United States. In their own countries the people become generally familiar with our methods and with our medical and engineering equipment. Our textbooks are distributed in Spanish and in English, and the result is the establishment of the technical leadership of the United States in those fields to the extent that it is qualified. Also, the physicians, engineers, nurses, and other experts from the foreign country come to maintain personal and professional relationships with similar professional people in the United States. And, in turn, the members of each Field Party of The Institute of Inter-American Affairs return to the United States with a full, detailed knowledge and appreciation of, and affection for, a foreign country and its people. Here, then, we have genuine collaboration between the professional peoples of two countries, based on a real working together with science as the common ground.

The same is true of the Cooperative Food Supply Programs. Agricultural experts from the United States go to live in a foreign country to work with the Ministry of Agriculture and the farmers. They take with them a first-hand knowledge of modern agricultural techniques and practices, which invariably are well received because they enable the local farmers to produce more and to make more money. Some of these farmers come to the United States for study and training in modern agriculture and farm management. In addition, they become familiar with United States equipment and publications. Hence, in the Cooperative Food Supply Programs the agricultural populations, which constitute the great bulk of the people of most Latin-American countries, actually work with our agricultural technicians, with science or technical skill as the common ground, to accomplish objective results of benefit to both countries.

In the Cooperative Educational Programs distinguished educators from the United States go to the Latin-American countries and work with the Ministry of Education and directly with the teachers in the schools. Latin-American educators come to the United States to study and exchange ideas, methods, and experience. Textbooks and other teaching aids and materials are jointly prepared for use in their countries, embodying advanced ideas and pedagogical methods adapted to the foreign conditions. Here, too, is working collaboration between the professional people of two countries, with science or technical knowledge and skill as the common ground.

The professional people are as a rule the leaders of public opinion in every country. When there is a genuine and substantial close working relationship between them, they are bound to understand and respect each other and the conditions in the other country. Their ideas naturally gravitate toward common denominators and a common point of view on the fundamental factors of society. Such collaboration between peoples entirely transcends the traditional concept of diplomacy, of formal relations between two men or a small group only. It is this sort of active, working collaboration between professional people of two countries, with science as the common ground, which can provide a solid foundation for mutual understanding and respect on a continual day-to-day basis.

With the establishment of such a foundation of mutual understanding and respect between the peoples of the world, international relations must necessarily take on a new aspect and thus provide a new harmony and security for the peoples of the world.

BOOK REVIEWS

THE TASK OF EDUCATION

Problems of Men. John Dewey. 424 pp. $5.00. Philosophical Library. New York. 1946.

THOSE who have read John Dewey's other books on philosophy and education will not find much that is distinctively new in this volume, but they would be ill advised if they failed to enjoy at least some of the timely and stimulating essays it contains. A collection of articles and reviews which originally appeared in various educational and philosophical journals, it is divided into four sections: Part I is concerned with the general problem of "Democracy and Education"; Part II contains essays centering around the subject of "Human Nature and Scholarship"; Part III, the most technical and difficult pages to follow, tackles the complex problem of "Value and Thought"; Part IV gives a brief but rewarding discussion of three philosophers: James Marsh, William James, and Whitehead. The variety of subjects treated in these articles, written at different times and for different occasions, is welded into thematic unity by the author's consistent philosophy of instrumentalism, which he applies boldly to almost every aspect of life and thought: education, ethics, psychology, epistemology, politics, and so on.

John Dewey is a courageous as well as clear-minded spokesman on current educational issues. He believes that teachers cannot—and should not—shuffle off their responsibility for dealing intelligently with the difficult social problems of their time. It is their duty, he maintains, to join professional organizations, to cooperate with labor. This, he feels, would greatly increase their economic literacy and at the same time strengthen their economic position. He protests strongly against the dichotomy established by the proponents of "liberal" education between liberal education and vocational education—a thesis which is also developed in part by another recent book *Education for Modern Man* by Sidney Hook. It is the technical subjects, now so urgently in demand, which must be given a human cast and perspective.

In analyzing the relation between authority and freedom, stability and change, Dewey stresses the need for the application of organized collective intelligence as illustrated by the scientific method. The philosophy of liberalism, too, must be revised, disentangled of its misleading and false elements. Liberalism, as Dewey would like to reconstruct it, would reassume its historic and creative role by recognizing that the individual is not a fixed datum but something achieved in a cultural environment. Liberalism of this type is important because it emphasizes the fact of historical relativity, the factor of change, the idea that the character of the individual and the concept of freedom take on different values in the course of time. It is opposed to absolutism and authoritarianism in any form. Belief in historical relativity validates the experimental method and makes the connection between the two functionally explicit. There is nothing mysterious or forbiddingly technical about the experimental method; it is predicated on the maximum use of pooled social intelligence in the inception and consummation of change and thus stands at the opposite pole of both entrenched conservatism and reckless radicalism.

In replying to the attacks that have recently been leveled against the scientific method and the philosophy of science, John Dewey hoists the Neo-Humanists, the prophets of tradition-

alism, and the metaphysicians of the supernatural with their own petard. He takes up the various charges that have been hurled against science in education. The teaching of scientific subjects is condemned as being too narrow in scope, whereas literary subjects are awarded the palm as being truly humanistic. Science, it appears, concentrates on the utilitarian, the practical, the vocational, thus marking a dangerous trend away from the human and the rational to the materialistic and the expedient. Though Dewey concedes that education today lacks unity of aim, he refuses to acknowledge that this is due to the impact of science and technology. Return to the classical models of the past, the revival of the medieval curriculum, would not be of any help. On the contrary, it would aggravate our hopelessly confused dualistic condition. The task of education is to march ahead, not to retreat to the past. The goal is not to reinstate "liberal" education as proposed by men like Hutchins and Adler but to humanize the content of vocational education, infusing it with meaning and purpose in the light of contemporary needs. To effect a release of human powers, to make for maximal human growth—that is the true meaning of being liberal. The attempt to re-establish educational materials and methods that were adapted to relatively simple conditions in the past is absurd and harmful in practice. It is opposed to all that we understand by freedom in a democratic country like America. The label "freedom" that these "liberal" educators use is but a euphemism. The faith that a miscellaneous collection of the hundred "best" ("best" for whom and under what circumstances?) can furnish an adequate educational diet is nothing short of laughable, Dewey declares. Such "reactionary" movements in education are to be combatted at all costs because they represent a frontal attack on the principle and method of experimental inquiry, the use of first-hand observation, the reliance on scientific method.

The same strictures apply, Dewey argues, to the disputed field of morals, which he also subjects to scientific analysis and evaluation. The notion that the One and the Changeless is somehow superior to the phenomenal world of change must be hooted and booted out of court. Improved instruments of observation and experimental techniques reveal change and continuity everywhere in life. Equally pernicious is the belief that the subject matter of natural science is restricted in scope and of subordinate importance, confined to technical or practical matters. A dichotomy is thus introduced between naturalistic means of knowing and realms of spiritual or moral values where science must not intrude. But the factors of supreme importance actively at work in contemporary life are experimental science and experimental method in *all* fields of knowledge. The breach between "higher" and "lower," the supernatural and the natural, the practical and the ideal, has worked enough mischief; it must now be bridged once and for all.

Science is making steady advances in practically all departments of life. Hence it follows that science must be applied to the domain of social and moral knowledge as well as to purely "material" concerns. Why postulate an irreconcilable antinomy between science and morals as if the truths of morals are different in kind from those to be found in physics and biology? Fundamentally, the issue is one between consolidated dogma and experimental insight, authoritarian conclusions and intelligent observation controlled by the wisdom of experience. All this is in line with political democracy, which endeavors to settle differences by the open discussion and exchange of ideas, an ap-

proach which approximates to the scientific method. It is the opportunity as well as responsibility of philosophers to make clear this deep connection between democratic processes and the scientific method.

The defense of science and the scientific method constitutes the spinal thread of the book. Science is being assailed on the ground that it has no relevance to essentially human, moral, and social problems. The quarrel boils down to this: Who shall be given the authority to direct life? Dewey contends that there can be no divorce between pure and applied science. Empirical philosophy looks upon science as being the only discipline that provides valid means for learning the truth about man and the world in which he has his being. Such acknowledgment of the value of science does not destroy the need for philosophy, which still has a vital function to fulfill. Philosophy makes it possible for man, once he has obtained the fullest possible knowledge about himself and his environment, to decide what ends he should pursue and what means can best realize them. There is urgent need for applying the scientific point of view in the schools. The established scientific curriculum is inadequate because the subject matter of science is still treated as a special and separate body of facts.

If the authority of science has tended to decline in our day there must be "good" reasons for the decline. Science first won its signal victories in transforming beliefs relating to "practical" matters. It ousted superstition and wishful thinking, it revolutionized commerce and industry, and so it seemed as if science were a highly specialized activity reserved for scientists in the laboratory, not a frame of mind with which human beings confront the challenging problems of life. Yet that is the goal which ultimately has to be reached. The material applications and technological triumphs of science are but the negative side of the picture. The experimental method of intelligence has never yet been used and applied to social problems. The vast knowledge we have gained in the physical sciences must be paralleled by an equally fruitful degree of progress in knowledge that can be applied to human desires and purposes. For human nature is not unchangeable; it is indefinitely plastic and malleable. Education can be put to use to create new ways of thinking, feeling, and believing. Dewey is convinced that when the science of man is developed to as high a pitch as physics or chemistry, it will concern itself with the fundamental problem of how most effectively to modify human nature.

That, substantially, is the message Dewey articulates in *Problems of Men*, a book which carries on the ideas and the faith to which he has devoted himself over a long and remarkably productive career.

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THE STORY OF AVIATION MEDICINE

Through the Stratosphere: The Human Factor in Aviation. Maxine Davis. 253 + viii pp. $2.75. The Macmillan Company. New York. 1946.

THIS is an incredible book. It is unbelievably comprehensive, and one which truly accomplishes what it sets out to do. It does this, moreover, in an effective, easy, reportorial style. This is accomplished in spite of the necessity for telling many complicated details: the necessity of narrating technical explanations which are essential to the story. What is this story?

The opening sentence of the book states: "This book is the story of aviation medicine." This is true. One must recognize, however, the basic fact that "aviation medicine" embraces all that

body of knowledge, practices, and beliefs which pertain to the *welfare* of the flyer—in this case of the Army Air Forces. Aviation medicine begins, for the flyer in the AAF, with selection, both on psychological and medical grounds; it continues in the field of preventive medicine and physiological hygiene where training the flyer is concerned with the care and use of all the equipment which is necessary to enable the flyer to cope with altitude, pressure, accelerations, impacts, and other aspects of flying in an environment which is strange to earth-bound man, and in situations too hazardous to be sought after by men accustomed to comfortable and routine domestic lives. Aviation medicine strives to judge the fitness—both physical and psychological—of the flyer and to admit to flying status only those whose performance of their duty is not a liability to themselves and to their companions. It initiates, advises, and supervises the design and development of special equipment. All of this is set forth—interestingly, compellingly—in this book.

The method of telling the story is simple. There are six sections in the book, with one to nine chapters each. The first is orientation—or setting the backdrops of an all-inclusive cyclorama. Miss Davis tells us that she spent a total of three months in virtually every active, combat U. S. air force around the world. She traveled over 35,000 miles by air. She saw, apparently, whatever she needed to see or desired to see. Most important, she had expert guidance both in the field and at home. The second section is the story of assembly-line applied psychology—that of cadet selection. This is *the* story in words that the high school student can understand. Next is a section on the special environment of the flyer, off the ground. This sets the stage of the story and prepares the way for the fourth section. The fourth deals, one by one, with specific problems of combat flying and the means by which they were solved. A fifth section is concerned with survival and rescue in the jungle—and the "rescue" of men whose minds have broken, for a time, under the stress of living on the false ground swell of combat. The final section does honor to the flight nurses, to the system of air evacuation, and hospitalization. In each chapter, the technique of telling the story is similar: state the problem, give examples for illustration, then tell the solution which the air forces through the air forces medical services adopted.

Miss Davis has obviously had available to her many official documents and very expert guidance through headquarters, AAF, and in the combat air forces from top to bottom. To anyone who knows the emphasis on certain topics and the history of certain developments as situations arose during the war, it is clear that Miss Davis had the "official line." It is correctly set forth, no doubt about it. To those who shared in these situations when what is now history was then the present—or worse, unknown—the development of this story was at times more hectic and less planned than it is made to seem in this book. For example, in the story of the "Air Force's Handy Man," the Personal Equipment Officer is made to sound as if, when the need was obvious, he of course had the solution—before too long. Would that this had been so! It is a fact that when nearly a hundred officers had been brought from every part of the country to Florida for three-week periods over a period of five months—at considerable cost in E bonds—there was no recognition on the part of top sides—from Headquarters AAF to headquarters of many of the Air Forces—sufficient to provide more than "paper" backing to the original directive of General Arnold that the duties of this officer would be fulfilled in every flying unit in the army air forces. This

was true to a lesser extent of other developments in which many high-ranking officers take pride today. Except for the force and foresight of a handful of men strategically placed in the air forces and in headquarters, the over-all program would have been far less successful than it was. Miss Davis rightly stresses General Grant's role as Air Surgeon. It is a fact, moreover, that certain officers from the Office of the Air Surgeon were insistently forceful, so that it is now possible to tell this story well, as has been done in this book. Many statements are exaggerated, but justifiably so, for their storytelling effect. The name of this book—*Through the Stratosphere*—has little bearing on its content. On the other hand, the subtitle—*The Human Factor in Aviation*—*is* the story! Part of the same reportorial exaggeration appears effectively in telling how meals were available on long hops with the ATC. This does not fit the case in some instances. After conditions became stabilized the situation did improve. But the description of delicious meals served in the sky is a taunt to the memory of this reviewer who, on an eleven-hour jump over the Sahara from Marrakech to Dakar, was required to pay one American dollar for a single chicken sandwich delivered mysteriously to the airport from the *boulangerie et patisserie de M. Marmouk,* or some such name. Some five hours later, it was less than reassuring, with this as the only food around, to see across the aisle a flight-companion struggling with his half-eaten sandwich from which protruded amidst the lettuce a fat, squirming worm of doubtful antecedents and associates. There are a few gaps in this book, but it would be as unwise as it would be impossible to tell the entire story. One wonders, for example, how there is only passing allusion to the notable work of a group of aviation physiologists whose effective work in altitude indoctrination brought results, if not recognition. It is a wonder to the reviewer how Miss Davis ever flew around the world and over the Hump without passing through even a single indoctrination "flight" in an altitude (low-pressure) chamber. Even "chairborne pilots" were indoctrinated—by the hundreds, if not thousands. One suspects that Miss Davis did not see at first hand the work of the training forces in the United States.

Still another omission or oversight is the flak suit—a most notable contribution to the success of our combat flyers, which originated in the aviation medical services. It receives but scant treatment in proportion to its value and that of some other topics included in the book. Similarly, while there is some reference to the role of dinghy drill and air-sea rescue in general, it is a fact that the agency in the air forces which made the operational training units accept the necessity for adequate training and preparation of the air crew in air-sea rescue training was the medical department. To one who has sat alone in a dinghy in the Irish Sea, off the Delta of the Wyr in mid-December, and then seen forty, fifty, and even sixty American men go down in the North Sea (noted on a large map in the Control Center at Chatham in the Thames Estuary but unsaved), the success attending American efforts to prepare the flyer to save himself takes on real meaning. The Office of the Air Surgeon was probably as responsible as any other single agency for the record of success that attended Air Forces' efforts in this direction, through initiating training and through persistence.

These are small points beside the success which Miss Davis has achieved. Her book should appeal to families and friends of men who fly; to the thousands of unsung ground-echelon men who lost, or never had, a perspective of the whole stage on which their little act was played, monotonously perhaps, but

where it was nevertheless a vital role. There is a breezy femininity about this book that makes it a distinct pleasure to recall regulations, circulars, letters, and orders. If the layman is momentarily fazed by reference to a "full-blown vicious circle of peripheral circulatory insufficiency, tissue anoxia, and marked hemo concentrations," he may find a moment of pleasure in associating this *hemo* with a brand of chocolate milk enricher available on the shelves at the local supermarket. He will not have lost much in not knowing the nickname of hemoglobin. For this reviewer, it brought back a fading memory of the time when *hemo* had no other meaning than that of a quick, one-glass lunch, to be eaten in three minutes while standing at a Snack Bar in the Pentagon. "Ulcer Clinics," we called 'em.

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PROLEGOMENA TO AN INQUIRY IN THE PROBLEMS OF MEDICAL CARE, III*

A Future for Preventive Medicine. Edward J. Stieglitz. xiv + 77 pp. $1.00. The Commonwealth Fund. New York. 1945.

This monograph is the third of the now well-known series initiated by the New York Academy of Medicine Committee on Medicine and the Changing Order in its effort to secure objective data on the reciprocal effects of medicine and the technological, social, economic, and political changes that have taken place in American life. The Committee believed that such monographs will offer not only a survey of the present situation but will also indicate its evolution and possible future trends.

Dr. Stieglitz presents his discussion of a future for preventive medicine under four headings, as follows: I, Definitions; II, Health Over the Last Forty Years; III, A Program for Preventive Medicine; and IV, Summary. His discussion is based upon a definition of preventive medicine which includes two broad areas of operation characterized by the mass and individual approach, respectively. The mass approach attempts to control the environment, making it innocuous, such control being the responsibility of the public health and sanitary services. The individual approach, on the other hand, has for its objective the prevention of undue health depreciation by attempting *construction* of greater individual health.

The author points out that present-day medical practices place relatively little emphasis on the individual approach. Interest continues to be centered on disease rather than on health, which should be a major concern of preventive medicine. Three factors appear to be responsible for this situation: Unwillingness of the individual to assume responsibility for his own misfortunes; inadequacy of present knowledge of causation of disease, particularly the failure to recognize that causation is always a combination of many factors; and the precept of medical ethics forbidding the practitioner to give guidance unless his aid is voluntarily sought. The last factor is qualified with the thought that "until people as a whole are educated to the point where they will cease to wait for pain, weakness, or fear to drive them to their physicians, preventive medicine will continue to be the backward child of medical practice."

The second section of the monograph presents a thoughtful statistical appraisal of health in the United States over the past forty years with appropriate emphasis on the changes in age structure of the population. The author proceeds to discuss the age factor in its relation to the two major areas of preventive medicine, the environmental con-

* Monograph I was reviewed in The Scientific Monthly, 60: 319–320 (April 1945); Monograph II in the same journal, 60: 471–473 (May 1946).

trol and the health practices associated with the individual. In the first instance the etiology is exogenous and obvious; in the second it is endogenous, occult, cumulative, multiple, and distant in time. The onset, on the one hand, is florid; on the other, insidious and asymptomatic. In the infective disorders typical of youth the course is acute and self-limited, with immunization and little individual variation; the degenerative disorders common in senescence are chronic, progressive, nonprotective, and present great individual variation. The author concludes from these observations that a preventive program, if it is to go beyond environmental control, "must remain a hope until such time as the complex etiological patterns of these [degenerative] diseases are thoroughly understood."

The second section also presents an opportunity to the author to record briefly some thoughts on the profound effect of progressive disability on the family, on the community, and on society in general. The author questions the soundness of the doctrine that the strong shall help the weak and so introduces a number of corollaries which will not be found particularly acceptable to some of his readers. The whole subject with its many ramifications is broader than the discipline of preventive medicine itself, and perhaps Dr. Stieglitz will devote a volume to it at some later date.

The third section is devoted to a program for preventive medicine, all recommendations being considered by the author as tentative suggestions. Development must be along both mass and individual lines. As has already been indicated, the first has to do with measures minimizing health hazards in the environment, whereas the second deals with private health efforts concerned directly with the individual, hoping to increase his ability to cope with unavoidable, undesirable environments.

For the advancement of preventive medicine the following activities are suggested:

> (1) Continuation and expansion of the present public health approach; (2) further research into the epidemiology of diseases guided by current data on morbidity and mortality; (3) coordination of preventive and health activities; (4) health education under the direction of physicians; and (5) introduction of individualized constructive medicine for adults.

Dr. Stieglitz has performed his assignment well. I would direct attention particularly to the author's emphasis on the necessity for shifting the focus of medical practice from the disease to the patient; his reminder that the causation of disease is always a combination of many factors; his recognition that the pictures displayed by the morbidity and mortality data of a given population are by no means identical; his insistence on the availability of morbidity and mortality data for the purpose of determining where, when, and under what conditions ill-health is occurring; his definition of preventive medicine which he has expanded to include health construction; his expansion of the conventional objectives of therapy to include that of control; his presentation of the elements differentiating the mass approach from the individual approach, particularly the role played by the patient: in the individual approach the role is an active one, whereas in the mass approach the role is largely passive, requiring little effort and interest; and finally his firm belief that health is a privilege, and hence there exists a personal responsibility for health maintenance which is an obligation to family and society as well as to self.

The book has a good bibliography and index. The typography and binding are uniform with the two earlier volumes of the series.

I feel that some reference might have been made in the monograph to the "Peckham [England] Experiment," be-

gun in 1926, which makes use of the family as the unit for individual health maintenance and health building. A cursory examination of the well-chosen bibliography revealed two minor errors.

This interesting, well-written, and thought-provoking book is unhesitatingly recommended to all health workers and others interested in making possible optimum health for the citizenry of this country.

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HAUSMAN'S FIELD BOOK

Field Book of Eastern Birds. Leon Augustus Hausman. xvi + 659 pp. Illus. $3.75. G. P. Putnam's Sons, N. Y. 1946.

This volume is an addition to the well-known series of "nature field books" published by Putnam's. However, unlike most of the other volumes in the series, it is not a manual for a group hitherto not so treated and consequently it will have to compete with established favorites, such as Peterson's *Field Guide to the Birds . . . Found in Eastern North America* and Chapman's *Handbook.* More abundantly illustrated than Chapman's volume, the present book is less adequate in this regard than Peterson's, although nearly every bird is figured, mostly in little black-and-white cuts which do not lend themselves too readily to comparison. The six colored plates containing 94 birds are not too well printed, the colors being too bright and losing the subtle modulations of tone that the originals probably had. The birds are very well drawn; their poses and action are good. All the illustrations are the work of a newcomer to the ranks of bird artists, Jacob Bates Abbott. Unfortunately, a few of the black-and-white sketches, such as those of the purple finch and the summer tanager, are in themselves not particularly identifiable.

Each bird has a separate page devoted to it, headed by the common name, the scientific name, the size, and a black-and-white drawing of the bird. Immediately below this figure each page has the pertinent text divided into conveniently marked paragraphs: Other Names, Field Marks, Field Description, Characteristic Habits, Notes, Habitat, and Range. Besides this, each family is prefaced by a Field Key, while the main body of the book is started off with a Field Key to Bird Families. A bibliography and an index complete the volume.

As a field book the present work suffers by being heavier and thicker, less adapted to a pocket, than Peterson's slender volume and seems to the reviewer less readily usable for quick identification in the field. On the other hand, Hausman gives the reader more information about each bird than does Peterson. The number of bird students is so large, however, that some will no doubt prefer Peterson's type of book and some Hausman's.

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SCIENCE ON THE MARCH

BAFFLING FOSSILS

Of all the extinct multitude of plants and animals that once inhabited the land and waters of the earth only a relatively small number left identifiable remains or traces as fossils. This incomplete fossil record, although a challenge to the reconstructive talents of the paleontologist, is, nevertheless, often dismaying, particularly when the dating of strata is urgently desired. Many fossils, obviously, have no living counterparts, and the paleontologist accordingly must erect categories of classification based on such analogies as he can find. Other fossils, although their relationships may be transparently clear once the correct clue to their identity has been found, may remain unidentified for years as tantalizing, baffling objects. In my office at the United States National Museum I have a drawer marked "Unsolved Mysteries" for the reception of such unknowns until time, patience, and further information bring enlightenment. Recently I had the satisfaction of solving one of these mysteries. The story, in detective style, might be called "The Case of the Fossil Fish Eggs."[1]

In the 1870's, Orestes St. John, a geologist studying the coal-bearing strata near Raton, N. M., found many specimens of fossil plants, including large fan-shaped impressions of palm leaves. These eventually reached the National Museum where they were studied and stored. About ten years ago, when curating this collection, I discovered among the palms several curious impressions that, presumably because of their markings, had also been considered palms. Some features of these impressions, however, seemed to me not characteristic of palms nor, for that matter, of any other organisms with which I was familiar, and I therefore removed the specimens to the drawer of problematica. Nothing further developed in this connection until late in 1944. Returning from field work in Alaska, my colleague Don J. Miller, of the U. S. Geological Survey, brought in a collection of fossil plants among which was a well-preserved impression that immediately reminded me of the puzzles from New Mexico. With this spur and the recognition that all these fossils were collected from brackish water or marine strata, I redoubled my efforts at identification by turning from the consideration of fossil plants to possibilities among marine animals. Thus I was presently led to the reading of a paper by Theodore Gill in 1905 reporting an egg capsule of a chimaeroid fish collected by N. H. Darton from Cretaceous strata near Laramie, Wyo. When I brought my specimens and conjectures to C. W. Gilmore, late curator of fossil vertebrates at the National Museum, he astonished me by producing Gill's specimen, of the location of which I had been unaware. It clearly confirmed the identification of the New Mexican and Alaskan fossils as similar egg capsules. Delving further into the literature I then found that Gill had been preceded by Emil Bessels, who in 1869 identified chimaeroid capsules taken from Jurassic strata in Germany. These had puzzled a scientific society at Württemberg for forty years, some members thinking the specimens represented crustaceans.

The chimaeroid fishes, named from the genus *Chimaera*, are sharklike in appear-

[1] Brown, Roland W. Fossil egg capsules of chimaeroid fishes. *J. Paleontology*, **20**: 261–266. 1946.

ance but are neither sharks nor ancestral sharks. Today they comprise about twenty-five species. They occur in all parts of the world, some in shallow, coastal waters, and others at abyssal depths. They display varied coloration, have powerful dental plates, and repro-

.52 natural size

FIG. 1. FOSSIL EGG CAPSULE

SPECIMEN SHOWING THE CENTRAL EMBRYO CASE SURROUNDED BY A THIN RIBBED MEMBRANE. FROM THE CRETACEOUS NEAR LARAMIE, WYOMING.

duce by laying dartlike or elliptic, tough, leathery egg capsules, somewhat after the manner of modern skates. These capsules consist of a central embryo case that is surrounded by a thin membrane of variable width with riblike thickenings, simple or branched. At the proper

.78 natural size

FIG. 2. LIVING EGG CAPSULE

THIS CAPSULE, DEPOSITED BY A CHIMAEROID FISH, WAS COLLECTED NEAR MISAKI, JAPAN.

moment a valve on the lower side at the fore end opens and permits the young fish to escape. The adult fish is approximately four times the length of the egg.

The fossils compare well with the egg capsules of a number of different genera of chimaeroids. Gill's specimen (Fig. 1), for example, is very similar to the capsule of the living *Rhinochimaera pacifica* from Misaki, Japan (Fig. 2). Eight fossil specimens are now known, and these I have divided among six species—two from the Jurassic; three from the Cretaceous, and one from the Oligocene. Judging from the large number of species assigned to the chimaeroids on the basis of fossil teeth, one must suppose that the Cretaceous was the heyday of these fishes. As the fossil egg capsules occur in strata that represent deposition in relatively shallow brackish or marine water, they may be valuable for stratigraphic purposes when they become better known.

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RIBOFLAVIN AS A FACTOR IN THE ADEQUACY OF THE AMERICAN FOOD SUPPLY

In 1941 the Williams-Waterman Fund of the Research Corporation made a grant to Columbia University in aid of a survey study of riboflavin as a factor in the problem of the nutritional adequacy of the American food supply.

The plan was to ascertain from critical compilation of previously published evidence, supplemented by additional determinations where needed, the riboflavin content of the average American food supply and to compare this with the nutritive requirement as found by other investigators.

Our starting point was the annual per capita consumption in the United States of each article of food which plays a significant part in our nutrition. The quantities of food commodities thus used were those derived by Lane, Johnson, and Williams[1] from official sources; these were also used by Cheldelin and Williams[2] for similar estimates of other vitamins of the B group.

Cheldelin and Williams'[2] estimate of riboflavin consumption in the United States was 1.4 mg. per capita per day before, and 1.6 mg. after, the introduction of flour and bread enrichment.

Applying to the same data of commodity food consumption new averages for riboflavin contents of foods, we estimated the (U.S.A.) per capita consumption at 1.8 mg. of riboflavin per day. That our estimate was higher than that of Cheldelin and Williams is owing to the fact that our average findings for riboflavin in individual foods, obtained by collating all available evidences from previous work as well as that of our own laboratory, tended to run somewhat higher than the averages of the determinations made by Cheldelin and Williams and used in their estimates.

Our experience indicates that with many foods more precautions are needed if the assay methods now commonly used are to reveal the full riboflavin content. We have not, however, been able to investigate this point as fully as seems desirable. Of late there has been a natural inclination to adopt as conclusive any findings in which *in vitro* determinations and micro-bioassays agree. There is, however, still the possibility—not only theoretical but concretely suggested by some very careful animal-feeding assays—that both the *in vitro* method and the micro-bioassay may yield low results with some foods. An unprecedentedly comprehensive research upon the quantitative determination of riboflavin in foods of all types and using all three types of assay (*in vitro*, microbiological, and animal feeding) might be well justified.

Meanwhile the United States Department of Agriculture has made new offi-

cial estimates of annual per capita consumption of foods by our civilian population. Also, newer figures for average riboflavin contents of foods have come into use. The data determined in the Columbia University laboratories have been merged with other data by the U. S. Department of Agriculture and the whole combined with data gathered by the National Research Council in making the table of nutritive values of foods now published through the Government Printing Office as *Misc. Publ. 572* of the U. S. Department of Agriculture.

These data lead to estimates[3] that our average riboflavin intake in the United States was in 1935–39, 2.0 mg., and in 1943, 2.3 mg., per capita per day. This gain of 15 percent is attributable in part to the enrichment program and in part to the gradually growing use of milk in our national dietary.

In 1941 the National Research Council published the now familiar Recommended Dietary Allowances for people classified according to age, sex, and activity. Those for riboflavin corresponded to a recommendation of 2.2 mg. per capita; but in the revision of 1945 the figures for riboflavin corresponded to 1.8 mg. per capita per day.[4] This change is because of downward revision of the allowances for adults (other than women in pregnancy and lactation), based chiefly on the findings of experiments such as those of Keys and coworkers[5] with young men. These experiments as reported by their authors "indicate that normal young men suffer no physiological or clinical handicap by restriction to an intake of riboflavin of 0.31 mg. per 1,000 calories for a period of five months. . . . Undoubtedly such a restricted diet does not provide a body reserve as large as would result from a greater intake." By comparison with such experimental evidence as this alone, it would appear that even the 1945 recommendations of the National Research Council carry a comfortable margin of safety; but there are other facts that should be considered lest we indulge a mistaken sense of security.

The five months' period of riboflavin restriction in the above experiments is only a fraction of one percent of a normal human lifetime. From animal experimentation we know that similar riboflavin restriction, extended over much longer segments of the life cycle without evidence of handicap, may yet result in premature aging and must be expected to shorten life. Hence a "code" of recommended allowances set up to cover all ages—and so, by implication, entire lifetimes—should in our opinion not be so much influenced by experiments covering only a very small fraction of (presumably) the most resistant part of the life cycle. For, the more comprehensively the evidence is studied, the more clearly it appears that riboflavin allowances should provide liberal margins. Two distinct reasons combine to support this view. First, when we extend our consideration to successive generations, animal experimentation shows that even at levels so liberal that further increase of intake has no further effect detectable in the original subjects, offspring may yet derive additional benefit from higher levels of intake of riboflavin in the family dietary.[6]

A second major reason for seeking liberal levels of riboflavin in our American food supplies is the fact that distribution is very uneven. With an *average* intake only slightly above minimal adequacy, an undue *proportion* of family dietaries are in constant danger of a shortage of riboflavin. There are both geographic and economic areas of undue hazard in this respect. The several governmental studies made by Stiebeling, Phipard, and others, show a high proportion of low-riboflavin dietaries among Southern families. This is clearly attributable in part to the geographic rea-

sons for shortage of milk in much of the South. But it is largely economic because in the North also low-riboflavin dietaries are found rather frequently among low-income families, especially those living in cities.

We must therefore conclude that inadequacy of dietary riboflavin is a more prevalent hazard in the United States than would appear from a merely casual consideration of current estimates of food supplies and nutritional requirements. There is need of more comprehensive and critically precise knowledge both of the riboflavin contents of foods and the riboflavin requirements and interrelations in metabolism, as well as the significance of bodily stores of riboflavin to individuals and their offspring. Meanwhile, in the interest of nutritional well-being and public health we should seek, as matters of public policy, both the fullest possible development of the enrichment program and a larger use of riboflavin-rich foods among low-income people. Fortunately, the food management policy which looks to wiser conservation and use of protein should also result in raising the level of riboflavin contents of low-cost dietaries.

Further research will doubtless make clearer the significance of riboflavin in nutritional well-being, and with increase of clarity should come increase of educational and governmental emphasis upon this important factor in the nutritional improvement of life.

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THE ACTION OF INSECTICIDES

EVERYONE must have marveled at the delicate mechanism of a woman's wrist watch, but it is a gross machine compared with the mechanism of an insect. Even a gnat that is barely visible has within its body nearly all the organ systems of an elephant, though they may be differently arranged. An insect has no bones in its body, but its skin, or integument, is sufficiently tough and rigid to support the muscles that move its wings or legs or mouth parts. It has an elaborate nervous system, sensory and motor, to enable it to find food and mate and avoid enemies. Its alimentary tract may be a tube leading straight from mouth to anus or it may coil and have blind alleys and by-passes along the way. It has no lungs, but, instead, tiny branching tubules, called tracheae, conduct air from openings (spiracles) along the sides of the body to all the tissues of the interior, eliminating the need for blood as an oxygen-transporting medium. The insect has a rather colorless blood, however, which is pumped by a tubular heart along the back from the tail to the head and circulates from head to tail through spaces and channels among the tissues. The excretory system, reproductive system, and perhaps an endocrine system need only be mentioned here.

The most numerous of terrestrial animals, insects have adapted themselves to all habitable environments, except the oceans. There is probably nothing of natural organic origin, living or dead, that does not provide sustenance for some species of insect. Reflecting their diversity, insects differ in structural de-

tails. One of the most important differences, from the point of view of chemical control of insect pests, is in the mechanism of feeding. Insects that consume solid foods, like the leaves of plants, can be killed by poisoning their food with so-called stomach insecticides; insects that consume liquid foods, sucking the sap of plants or the blood of animals, cannot be so killed. However, both kinds of insects may be killed by contact poisons, which, in contact with the surface of the body, enter it by some route other than the mouth. And both kinds may be killed by fumigants, the vapors of which enter through the respiratory system.

It has not been difficult to find chemical compounds that will kill insects; but it has been and remains difficult to find new compounds that give good economical control without injury to the insects' host or enemies or without hazard to the person handling or applying the insecticide. The human hazard is, of course, the most important, and the great differences between human and insect physiology suggest that there may be, awaiting discovery, chemical compounds that are lethal to insects and harmless to man under conditions of use. So greatly do conditions of use vary for different pests that no one insecticide is likely to solve the problem.

In the early days of chemical control entomologists were willing to use any economical poison that did little or no damage to the plant or product to be protected against insect attack. Thus poisons known to be deadly to all forms of animal life were used: arsenical stomach insecticides; nicotine contact insecticides; and hydrocyanic acid gas as a fumigant. It was hoped that accidents would not occur, but they have occurred and will happen again until more specific insecticides completely replace these toxicological blunderbusses.

Pyrethrum, the dried and ground flower heads of a kind of daisy, was the first effective but safe insecticide to come into use. It was not discovered by scientists but somehow emerged in Europe during the past century. As a contact insecticide it has a spectacular paralytic effect on many insects but has no effect on man, except for a few who are allergic to it. For many years entomologists wondered what compound could be responsible for the unique effect of pyrethrum. If it could only be isolated and identified, they thought they would hold the key to a storehouse of insecticide treasures. Finally in 1924 the answer came from Switzerland. Staudinger and Ruzicka reported that two complex esters, which they named pyrethrin I and pyrethrin II, were responsible for the insecticidal action of pyrethrum. Their work was confirmed by others, but the long-sought key eluded everyone. Knowledge of the molecular structure of the pyrethrins did not lead to the development of a single related synthetic insecticide. The slightest change in the pyrethrin molecule destroyed its toxicity.

Insecticide chemists and entomologists did not give up, however. They studied the tropical fish-poisoning plants called derris and cubé, isolated the active ingredients, determined the structural formulae of rotenone and related compounds, which were entirely different from the pyrethrins, and developed products of rotenone-bearing plants into widely used stomach and contact insecticides, second only to pyrethrum in safety to man. But again the knowledge of the complicated formula of rotenone did not lead to its commercial synthesis or to the synthesis of effective insecticides related to it. Like the pyrethrins, rotenone and its close relatives were unique. Nor has any other plant yielded the key to synthetic insecticides.

While the key was being sought by a study of natural insecticides, entomologists were trying all kinds of synthetic

organic compounds, hoping by hunch or by dumb luck to stumble upon an effective compound having desirable properties. Thus phenothiazine was turned up by a group interested in sulfur compounds. Its promise as an insecticide was not fulfilled, but it did prove to be a valuable anthelmintic.

Then in the nick of time (1942) came DDT [1-trichloro-2,2-bis (*p*-chlorophenyl) ethane] from Switzerland and a little later 666 (hexachlorocyclohexane) from England, both chlorinated compounds so simple in structure it was hard to believe that they had been previously overlooked.

The long, random, and often futile search for synthetic organic insecticides indicates that not enough effort was made to understand the toxicology of known organic insecticides or the biochemistry and physiology of insects. In the equation, insecticide + insect = death, the term "insect" was practically unknown as a physicochemical factor in the reaction. Efforts are now being made by a young and enthusiastic group of insect physiologists to develop intelligent hypotheses that can be tested and used to replace hunches in the search for still better insecticides. They want to know how insecticides kill insects. The "how" of lethal action involves at least two questions: how does the insecticide get into the body of an insect and what happens to it and to the insect after it gets there.

A stomach insecticide does not enter the body of an insect until it, or some reaction product, passes through the walls of the alimentary tract; a contact insecticide must enter through the outer integument of the body. It would not be hard to understand how a water-soluble insecticide might enter, but most good insecticides are highly insoluble in water, since their residues on treated surfaces are expected to resist weathering and retain their effectiveness for some time. DDT, for example, is so insoluble in water that only about one part per billion dissolves. How then can it pass through the chitinous cuticle of insects? To answer this question much needs to be learned about the microscopic and submicroscopic structure of the insect cuticle and its chemical and physical characteristics. It is known that the cuticle consists of at least two distinct layers: a very thin waxy outer layer and a much thicker inner layer, which always contains protein and usually a carbohydrate called chitin. The inner layer may be subdivided into a hard outer part and a soft inner part, the latter containing more chitin than the former. These layers may be laminated and penetrated by pore canals and sensory and gland cells. But much remains to be discovered by the use of biochemical methods, X-ray analysis, and the electron microscope.

The modern approach to the question of how insecticides kill may be illustrated by summarizing two papers that appeared in the April 1946 issue of the *Biological Bulletin*. The first by A. Glenn Richards and Laurence K. Cutkomp turned up a surprising affinity between DDT and chitinous cuticle. Their purpose was to study the relative susceptibility of aquatic invertebrates to DDT. Working at Woods Hole where they could get representatives of the various phyla from protozoa to arthropods, including insects, they prepared very dilute suspensions of DDT in fresh water or sea water in which to immerse the various organisms. Samples of each species of animal were placed in a series of suspensions of known concentrations, and the effects of DDT on them were observed. Only the chitinous arthropods and certain coelenterates were highly sensitive to DDT. The susceptible coelenterates had a chitinous perisarc; the resistant coelenterates did not, nor did other resistant animals have a chitinous cuticle. So it appeared that insects were

sensitive to DDT *because* of their chitinous cuticle and not in spite of it. Going further, they found that adsorption of DDT from the dilute suspensions by chitinous cuticle and consequent concentration of the insecticide on the surface of insects was the first step leading to their great susceptibility. They demonstrated the actuality of selective adsorption in various ways: They found that charcoal, isolated insect cuticle, and pure chitin would remove DDT from dilute suspensions, making the filtrate harmless to their biological indicator, mosquito larvae. And then they could recover the DDT from the cuticle and kill the larvae. Furthermore, they found that in the most dilute suspensions the effect on the larvae decreased with increasing temperature. As the quantity of a material adsorbed also decreases with increasing temperature, the unusual negative temperature coefficient was a strong indication of the predominant role of adsorption of DDT in the effects observed. But various other observations showed that adsorption, though important, was not the whole story. Here, however, is a new hypothesis bearing on contact action of insecticides. In searching for new contact insecticides a test for adsorption by insect cuticle might very well be used.

Reporting his work in the other paper, Dietrich Bodenstein explored the internal phenomena. He injected DDT into the body cavity of larvae and adults of Drosophila to determine its locus of action. It was already well known that DDT poisoning in insects is characterized by symptoms of hyperactivity and discoordination of the neuromuscular system followed by convulsions and terminating in death. These effects suggest action on the nervous system but more conclusive evidence was needed. Bodenstein found that a certain paralytic drug, phenobarbital, would prevent convulsions in Drosophila if injected prior to DDT or would stop convulsions if injected after DDT. Because a drug acting on the nervous system stopped the symptoms normally produced by DDT, it was reasonable to conclude that DDT acts upon the nervous system also.

Everyone who has seen tiny Drosophila, sometimes called pomace flies, must realize the delicacy of technique required for these injection experiments. But still more amazing were the subsequent experiments of Bodenstein in which he transplanted from larvae nearly dead from DDT to normal larvae or adult flies the tiny groups of cells called imaginal discs, which upon metamorphosis from larva through pupa to adult develop into the wings, legs, etc. These transplanted imaginal discs developed normally in their new hosts, indicating that DDT affected nerve cells only.

It might be added that the war is responsible for the present increase in knowledge of the action of DDT and other insecticides. Supported by the Chemical Warfare Service and the OSRD, many fundamental investigations have been made, and the resulting stimulation to research in insect physiology and toxicology should be evident in the future.

F. L. CAMPBELL

COMMENTS AND CRITICISMS

Our Everyday Reckonings

Professor Oystein Ore evidently needs someone to tell him that an article on the metric system, either pro or con, is by this time something worse than "old stuff"—thrice threshed straw that Americans—those who have any claim to speak on the subject—ceased picking over thirty-five years ago. The fact that an occasional bill is introduced into Congress, at the instance of some uninformed individual to make it compulsory surely does not warrant renewing the agitation on the old lines with which all of us—*engineers* at least—are so wearily familiar. There is not one single argument rehearsed by Professor Ore that was not thoroughly "winnowed out twixt world and world," like Tomlinson's soul, in my paper "The Metric vs. the Duodecimal System" given before the Am. Soc. Mechl. Engrs. at their fall meeting of 1896 and the appended discussions; plus the numerous writings on the subject by *engineers*—I will not say scientists—in the years that followed. If the metric controversy is not settled by now it's safe to say it never will be. It really belongs in the class with religion and politics, as just one of those things.

I am not writing this with a view to re-discussing the question. We engineers—for notwithstanding I rejoice in membership in the A.A.A.S. I cannot claim to be a scientist in the professional sense—really have no objection to such re-discussion, but the proponents ought to do what Gibbon advised his critics:—*read* before they try to *write*—so that we may begin at least where we left off; and *then*, if they expect to take any further action than "talk for Buncombe," inform us what they expect to do, or would have us do, about "introducing the metric system." They admit they have—have had for eighty years—a law *legalizing* the metric system, that is, *granting permission* for us to use it; just as if anyone in any nonmetric country needed any one else's "permission" to weigh and measure anything he pleased at any time he pleased and by whatever system or no system he pleased. But that law having failed to achieve their object, and after a century and a half we being no nearer than at the beginning to what they call "adoption," they now seek to make the use of their system *compulsory;* to forbid the process of weighing and/or measuring by any system except their system. Professor Ore now tells us (and it's not the first time we have been told) that "it even appears doubtful whether any compulsory legislation stands any great chance of being passed within the next few years"! Just how much chance does he think there will be of passing such a law in this country in the next hundred or thousand years? And how well will it be enforced if passed? Who wants it passed, anyway? We may answer the last question easily: the same people who put over the French system originally. Professor Ore cites thirteen of them; "the cream of European science," he says, but—all mathematicians and astronomers, not one of whom would be recognized, even in their own country, by the "man on the street" today. As against this lot of starry-eyed philosophers, consider the sort that an American Congress would pick out, the men who do things—Watt, Morse, Westinghouse, Edison, and so on, whom every man on the street knows about. None of such men laid claim to "knowing" either mathematics or astronomy, but any of such would consider themselves, and would be considered by us, as competent to determine the proper size of a pint-pot as the profoundest of intellects. These are the men who have made America great, whose name is gone out into all the earth, and their "gadgets" unto the ends of the world. If any such men ever appeared as the advocate of any law making the transaction of business (at least of their own business) according to some predetermined rule *compulsory,* we haven't heard of it. Any such law would be laughed to death anywhere in America, and I believe Professor Ore would be ashamed to appear in its support.

Since Professor Ore has favored us with a quotation from Secretary Adams' famous report, which he says is a "glowing tribute to the metric system," he should have gone all the way and informed us that in spite of such "glowing tribute" Mr. Adams decided *against* the metric system for America, and the words of his conclusion deserve quotation much more than those cited by Professor Ore: "Were the authority of Congress unquestionably to set aside the whole existing system of metrology, and introduce a new one, it is believed that the French system has not yet attained that perfection which would justify so extraordinary an effort of legislative power at this time" (p. 120).

I need only add that if such an extraordinary effort of legislative power was not justified at *that* time, its justification now—when Anglo-Saxondom is rapidly filling the entire globe and the other nations appear but pygmies alongside it—is infinitely less justified and not to be considered by anyone in his senses.—George Wetmore Colles.

Philosophy in a Nutshell

A philosopher, one Bishop Berkeley,
Remarked, metaphysically, somewhat darkly,
That what we don't see
Cannot possibly be
And the rest is altogether unlarkly.

There was a young man named Kant
Who developed a most extraordinary plant,
A thing out of season
Called the Critique of Pure Reason
Which proved what you can do when you can't.

M. F. Ashley Montagu

A Biologist Reflects Upon Old Age and Death

In his complete and logical rejection of the concept of personal immortality in the last part of his article in The Scientific Monthly (**61**: 144–149, 1945) Francis B. Sumner expresses, though far more ably than most of us could, the reasoning and conclusions of most of those who have thought at all objectively on the subject, or at least of those who have any sort of background in biology.

Any attempt to separate the destiny of human individuals from that of the rest of the animal kingdom, or, for that matter, the plant kingdom, is bound to collapse as an absurdity if the evidence is examined objectively and unemotionally. That all the phenomena of, and associated with, life, personality, and consciousness are properties of the particular aggregation of matter and energy that is called a living organism can hardly be doubted. Individuality and the great range of apparent intensity of consciousness are merely reflections of the variability and great range of complexity of these organisms.

The characteristic desire for, and belief in, immortality in human beings are easily enough understood as the result of the universal instinct for self-preservation plus the almost equally universal fear of the unknown. These two factors, with usually the addition of the ambition of some persons for control over their fellow persons, are responsible for most if not all of the multiplicity of religions that have characterized the history of all humanity.

In discussing these questions with intelligent nonscientific people, and even with many scientifically minded ones, the same objection almost invariably arises, and it is one which is not disposed of by Dr. Sumner's discussion, at least not in a way that would likely satisfy those who bring it up. This objection is usually worded something like this, "But if there is not an after-life what is the point to everything? What is the justification for all the effort, suffering, and sacrifice of this life? I cannot believe that life, with all its struggle and development, has no meaning."

The hard-boiled scientist might answer, "Why must human life have any more meaning than that of any other of the hundreds of thousands of varieties of life found on the globe? It is all a part of an evolutionary process that got started fortuitously many millions of years ago and has continued since because of certain characteristics in the makeup of living material that make it inevitable that it go on until exterminated by some unfavorable combination of circumstances which may occur on a world-wide scale. No meaning other than this is needed."

From the standpoint of cold logic and such factual evidence as we possess, such a position is probably unassailable. It is, however, from the human point of view, unsatisfactory. With this as the alternative, the ordinary thinking human will either turn to some form of religion or will attempt to drown his despair in hard work, social activity, or drink. Abstract meaning or suggestions of meaning of life as a whole will not suffice. To himself, each person is a very important individual entity and must have a significance manifested in terms of this entity. He is interested in the reason for *his own* existence, not in a faraway impersonal reason for the existence of the universe or of all life. And I dare say that this applies to most scientists, as well as to their colleagues in other, less objective, fields of thought. The number of religious scientists and the amount of speculation and discussion among scientists along these lines is ample evidence of this.

Many years ago while I was still in high school and still active in Sunday-school affairs I ventured to express some of the deep skepticism that I was beginning to feel about much that I was being told in Sunday school and church to a much older friend. Fortunately for me this friend was a very intelligent woman, one who, in spite of being active in church affairs, did her own thinking. To my amazement, her reply on the subject of immortality was, "Of course there is no such thing as life after death. The only immortality that seems possible to me is that of the effect you have on other people while you are alive." As long as I knew this woman she was serene and emotionally well balanced, though unusually active and hard working, in the face of more than an ordinary amount of hardship and misfortune incident to raising a large family.

Her remarks have given direction to much of my own subsequent thinking on the subject.

There seems little doubt that the lasting im-

portance and meaning of a person's life lies in his contribution to the emotional and intellectual richness of human life as a whole. Immortality in the ordinary sense has no place here, but measured in total effect on human life, the contribution made by an outstanding teacher, thinker, or creative mind may even outweigh immortality. Probably few people would demand a further meaning for the lives of Shakespeare, Schubert, or Beethoven than is evident every time their works are read or listened to. The lives of the parents of such individuals certainly do not lack significance, either, nor those of their teachers. One need not search far for the significance of the lives of such men as Galileo, Pasteur, and Darwin. Their influence will go on as long as human intellectual life goes on, whether its manifestations are recognized or not.

The above examples are used, not especially because their fame makes them immortal, but because every reader will know who they are and can understand the trend of the argument. If I were to mention one of my early science teachers, a woman who was for twenty years as a high school teacher much more than that, a guiding and molding influence in the lives of a constantly changing but very worth-while group of students, my argument would fall down from lack of familiarity to the reader, not because the example was not significant. This woman aided very materially in stimulating and training minds so they could understand and appreciate the works of the examples mentioned above, as well as doing a lot to make good human beings of her young friends. Significant personalities are usually so because of the composite effect of those with whom they have had contact, especially while young. The person who has exerted such an influence has frequently added materially to the general richness of human life.

It may be objected that, even granting all this, there are untold millions of people whose lives make no imaginable contribution. There are those who are potentially significant but whose lives are rendered sterile by circumstances or environment. There are those whose level of mediocrity is such that they have absolutely nothing to offer. There are also those who die young, those who are insane or feeble-minded, as well as many whose influence is all or largely negative, bad, or destructive.

This is granted. It may be asked in reply, "What significance would immortality have for these people?" I remember seeing somewhere a quotation to the effect that many people are greatly worried about whether or not they will live throughout eternity when they can't even find a way to spend a rainy Saturday afternoon. And what difference would it make whether an idiot were immortal or not? It would merely be prolonging an unfortunate condition indefinitely. As for those whose influence is destructive, there seems no reason to doubt that evil effects are just as far-reaching and permanent as good in many cases. The person who destroys, for whatever reason, something that gives emotional satisfaction to others, or who exercises a harmful effect on the minds or characters of his fellow humans may have the satisfaction, if satisfaction it is, of knowing that the evil he does will live on after him. I have noticed that the idea of punishment throughout eternity has apparently had little deterrent effect on most of these.

Waste is characteristic of many of Nature's fundamental processes. Thousands or millions of seeds or eggs may be produced of which only two are likely to become individuals which reach maturity and repeat the process. It neither surprises nor distresses me that there may be many millions of human lives in existence which will have no appreciable significance. The important thing is that in addition there were a Beethoven, a Pasteur, a Darwin, a Benjamin Franklin, an Abraham Lincoln, and the innumerable lesser-known ones who have contributed to the incredibly rich lives we are able to lead today.

To have the opportunity to contribute to the wonderful cultural heritage of humanity should give meaning enough to life for anyone. The quality of the contribution is becoming more and more dependent only on the inclination of the individual and upon his inner potentialities. Leisure and education are no longer restricted to the few.—F. R. Fosberg.

The Strange Trinity Called Man

The article in the April issue of The Scientific Monthly entitled "The Strange Trinity Called Man" should not be allowed to pass unchallenged.

One function of science is to acquire knowledge of the universe in which we live by the methods of observation and experiment; speculation as to those compartments of the universe which science is as yet unable to enter must be left to philosophy. These two functions are equally legitimate and the boundary between them is clearly demarked, but it is subject to continuous readjustment as our fund of scientific knowledge increases.

The position of psychology among the sciences is a peculiar one. The way in which the human mind works is certainly a legitimate object for scientific research, yet psychology is

the offspring not of science but of philosophy, and although in the recent past it has made significant progress in entering the family of the sciences it has not yet forgotten that it is a foster child. Its followers still tend toward speculation rather than experiment, and to assume a dogmatic rather than a ratiocinative attitude. Unlike the savants of science who can test their theories in the laboratory under controlled conditions, each psychologist is free to formulate his own peculiar beliefs which he can maintain against the claims of others, because there is as yet no method by which the values of rival theories may be reduced to a common denominator.

The article referred to is characterized by many statements of this sort which are capable of neither proof nor disproof, and not a few of them appear to be inconsistent with the facts. Among the latter is the statement that conventional psychology has always concerned itself with the conscious, and that psychoanalysis has recognized that human personality is like an iceberg, the bulk of which is submerged beneath the surface. As a matter of fact, however, the iceberg simile is far older than psychoanalysis, it having been used by that most classical of all students of psychology, William James. Further, it seems somewhat inappropriate to the psychoanalytic school of thought, which, to be consistent should logically require not less than three icebergs, two supported by surface tension and the third completely sunk.

The use of the term "id" is also to be deprecated. It was originated by August Weissmann for use in cytology and its later application to an entirely different object cannot but result in confusion, especially so because its use in psychology applies to a conception for which a universally understood term has long been in use—it is the subliminal self arrayed in fancy modernistic nomenclatorial garb.

The author's theory that composers give numbers to their compositions rather than names because they themselves do not understand the full import of their productions seems scarcely tenable. Mendelssohn, writing to Souchay, explained that he gave no names to his "songs without words" (the names by which these compositions are popularly known were given at a later date by Stephen Heller) not because the thoughts which evoked them were too indefinite to be expressed in definite language, but that they were too definite to be expressed in indefinite language. Tschaikowsky called his sixth symphony "program music," but said that its program was too intimate and personal to be shared with the public, and nobody knows what prompted Beethoven to remark "*So klopft die Schicksal an der Pforte*" just when he did.

That suicide may frequently result from intrapsychic strain is very probable, but the interpretations which the author gives of certain instances from life and literature are not always easy to follow. For instance, the case of Javert in Victor Hugo's novel is in point. One would think that the conscientious superego would have striven to protect Jean Valjean while the selfish ego and the irresponsible libido were clamoring for his destruction, and there is no apparent reason for the author's preference for an alternative interpretation.

When the author ascribes phallic significance to the Trylon and Perisphere at the New York exposition he appears to be doing violence to that fundamental unifying principle which underlies both science and philosophy, known as William of Ockham's razor. The explanation offered by the architect is simpler and more reasonable and in the absence of evidence to the contrary should be accepted. If these objects really had phallic significance, why were there not two perispheres? Would the author attribute phallic significance to the ice-cream cone, which is of the same shape as the Trylon, or the scoopful of ice cream which fills it and which in form resembles the Perisphere?

Finally the naive way in which this author has swallowed the ancient Mather-Penn hoax hook, line, and sinker is a real cause for astonishment. Further, the version of the letter used in the article here under discussion shows signs of having been expurgated. The more familiar form is characterized by a peculiar orthography which scholars tell us was characteristic of the eighteenth century, but not of the seventeenth.

One wonders if an author who accepts as true so many errors which can be so easily detected, in discussing a matter so well understood by everyone, can be trusted in those statements which he makes concerning matters on which authorities generally disagree and which cannot be subjected to any experimental test to verify or discredit them. If the blind lead the blind, shall they not both fall into the ditch?—JOSHUA L. BAILEY, JR.

The Strange Trinity Called Man

The editor's challenge to "come forward with contributions as clear and interesting" as Mr. Boyajian's essay on psychoanalysis sounds fair enough. In fact, it is not. Science, even popular science of the best sort, can seldom compete with literature. There is drama in scientific research for those engaged therein; it is indeed rare to be able to convey it to others.

The Freudian psychology, on the other hand, is almost straight drama. "Human personality, then, consists of these three persons: Ego,

Superego, and Libido. Conflicts within the trinity are eased by dulling the *censorious* partners and 'releasing' the Libido. At night the Ego sleeps much more deeply than the other two. The Libido takes advantage of the drowsy Ego and enacts its hopes in dramatic scenes.'' Thus Boyajian. Of course it is interesting. It has everything the playwright has used since the times of Aeschylus.

But is it science? Is it good popularization of science? Metaphor, simile, personification—these have their place *in* science, but they must never be mistaken *for* science. Most of psychoanalysis consists in attempting to elevate elaborate metaphors into scientific generalizations. It is interesting all right.

The editor, however, also calls Mr. Boyajian's essay ''clear.'' Here one must dissent. For clarity means much more than using familiar words in a sound rhetorical pattern. Clarity means pointing unambiguously at a particular thing. Take almost any of his sentences at random and ask yourself what are the actual referents. ''Subconscious workings of sexual energy.'' Try it. There is, of course, an actual ''sexual energy''—the whole activity of the sexual apparatus. But this is precisely not what the analyst is talking about. For him a complete hysterectomy may increase the ''sexual energy.'' What then is the sexual energy? What specifically is the referent of ''subconscious?'' Just what is meant by the interesting metaphor that a ''malfunctioning'' Superego may tend to *choke* the Libido? To call attention to a scientific principle by means of such a figure of speech would be magnificent; to substitute its vivid vagueness for the facts is mere verbal magic or legerdemain.

It was quite a task to rid natural science of demons, animal spirits, and all the other personifications of natural phenomena. We have almost completely succeeded. In the much contemned ''academic psychology,'' also, victory is close at hand. Even the more thoughtful of Freud's disciples recognize that the time for dramaturgy has passed.

Freud called attention to relatively neglected problems and by intuitive genius of the highest order discerned important principles concerning the motivation of human behavior. Perhaps it was right to set these forth first in the highly dramatic form he adopted: he got attention. Today a major task is to restate these principles so that they will have *clear* and unambiguous reference to concrete facts. That task will only be hindered by such flamboyant dramatization as we find in ''The Strange Trinity Called Man.''—HORACE B. ENGLISH.

The Strange Trinity Called Man

We are obliged to Paul W. Holloway for so promptly furnishing us an authentic letter to replace the unauthentic Cotton Mather letter mentioned in my article in the April 1946 SM.

One does not have to be a psychoanalyst to discern the poorly concealed murderous thoughts that this fundamentalist harbors against modernists, just as another Paul did before him against those who disagreed with him first on Mosaic law and later on Christian dogma. Paul Holloway would like to see all such as myself strangled, and, while he does not openly threaten to do it himself, he suggests that we hang ourselves and that I ''do it quickly''—he cannot wait for it!

One trouble with fundamentalists like Mr. Holloway is that they have absorbed neither the spirit of science nor that of Christianity. Worshiping Christ as King or even doing miracles in his name does not make one Christian (Matt. 7: 21–23); neither does collecting observations of physical phenomena make one a scientist (as Mr. Holloway implies in his letter). More than once Christ got away from a crowd that wanted to make him its King (John 6: 15, 22–26), while he welcomed an inquiring scholar of his day, by the name of Nicodemus, to sit down and talk it over with him, even though their understanding of the truth about man and God did not exactly agree.

The fundamentalists are afraid that the modernistic scientists want to discredit the Bible and overthrow Christianity. How foolish. This writer loves the Bible and thinks it is the most beautiful book: Greek and Roman classics are not to be compared with it. He has taught both adult and young Sunday School classes and believes in inspiration—that God speaks to man, to all men, and not only to St. Paul—even to Paul Holloway (if he would but listen to him!). Because the writer believes in inspiration, he is tremendously interested in learning its *modus operandi*. He believes that God is not an outsider to us but immanent in us: or, as others have said it, ''We live and move and have our being in Him.'' All our creative impulses (artistic, social, industrial) and all our urges to discover the truth (scientific, religious, philosophical) are the normal workings of that divinity in us.

Surely, the Kingdom of God is within us; and those that worship him shall worship him neither on this mountain, nor in Jerusalem, nor yet in Mr. Holloway's traditionalist and murderous Sunday School, but in Christian spirit and in scientific truth.—A. BOYAJIAN.

This is the last word on The Strange Trinity Called Man.—Ed.

Humanism

In a letter in the SM for April 1946 Mr. Harold Rafton states that "from any objective modern standpoint it must be conceded that the moral content of religions is the only lasting contribution that they have made to man's advancement." Mr. Rafton suggests that Christians and Jews should scrap "all supernatural, traditional, and folkway elements of their Faiths" and unite their identical moral codes because this would solve the "Jewish problem" and would bring both sets of religious ideas "squarely in line with current scientific knowledge." The letter is very nearly as naive and uninformed as the article (in the same issue) on Humanism by Dr. Archie J. Bahm.

In support of this contention I offer the following: from one of the most objective modern standpoints (that of A. J. Toynbee in *A Study of History*) it is demonstrated, by historical analysis, that the contribution of religions has been much more than the moral content alone: several religions have furnished the social institutions and organizations within which several civilizations have come into being. There are, of course, several other standpoints, but it is necessary to mention only one. (It may be, of course, that Mr. Rafton would not regard this as "a lasting contribution to man's advancement"; I am not sure. But if he would not so regard this contribution, then it would be difficult to imagine what he would define as a lasting contribution.) This is uninformed.

The suggestion that Christians and Jews should scrap all but the ethical elements of their faiths is naive (in the specific dictionary sense of "foolishly simple") because, "from any objective modern standpoint," it would not only be impossible but would achieve none of the results described by Mr. Rafton. It often happens that the individual who is committed to one set of superstitions is likely to regard all opinions other than his own as superstitions. It is obvious that Mr. Rafton is deeply committed to the current superstitions about "objective standpoints," the supremacy of "modern science," "rationalism" and—perhaps the callowest of all—"humanism" (in the Bahm sense).—E. D. Myers.

Humanism

Kindly permit a comment on the article "Humanism" by Archie J. Bahm (April SM); first column, second paragraph: "Science deals with facts and religion with values."

Science does not always deal with facts—it has often instead dealt with what the scientist believed to be facts. What science there was once dealt with a flat world, not a fact. Within a lifetime science considered the atom a single indivisible ultimate unit of matter, not a fact. One can greatly multiply such a list. Science dealt with them as facts, and they were not facts. Such "facts" have been proved by scientists themselves not to be facts. They were beliefs—science believed them to be facts.

Now we have new "facts," in their stead, that we believe to be true facts. There can be no ultimate proof of a fact because it is at least conceivable that some thought or action may depose the same fact and supply a new fact in which we anew believe. Also a fact is a value and a value may be a fact.

Science then depends on a belief in changing facts and on facts that it believes will never change. Science then depends on belief. Religion depends on belief. If the individual did not believe in his religion, he would have no religion.

They both seem to depend on belief and seem not to know it (belief) as a mutual unity.—William F. Howard, M.D.

Mildly Critical

Doubtless conforming to a spirit of emulation without envy, published failures to devise a good modern unified theory of an assumed materialistic universe relate largely to mathematical experimentation of a trial and error nature. These attempts seem foredoomed to continued failure for very cogent reasons, a few of which are cited.

First: Because it is known that one cannot get more out of mathematics than is put into it.

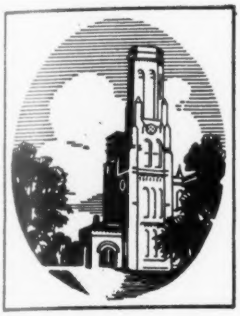
Second: Because of the fact that, on the materialistic assumption of individually unrelated and non-associated "particles," it is logically necessary to produce entirely separate and independent hypotheses for each and every one.

Third: For the reason that in all materialistic hypotheses there is complete failure to provide mathematical justification for the one exception proposed in the laws of chance, namely, the exception claimed of series of virtually infinite perfect coincidences, as a matter of chance, of practically infinite independent and unrelated recurrence of discrete, identical conditions, without a single known throw-off.

Fourth: No provision is made for the long term *maintenance* of matter and energy.

Fifth: Mathematicians and physicists, in their equations, ignore life and its phenomena. These must be consistently included in any workable unified theory of the known universe.—Chester B. Duryea.

THE BROWNSTONE TOWER



One day when I was a boy my chum and I sat on the fence of an automobile track while cars were warming up for a race. To our surprise one car pulled up in front of us, and the driver with a grin shouted, "How'm I doin'?" We assured him with enthusiasm that he was doing fine. But in the race that followed he brought up the rear. Since then I have tried to get facts before answering the question: How'm I doin'? I am asking that question now with reference to the SM. Are we covering the field of science with articles properly distributed among the chief branches? If not, what adjustments should we attempt to make? To determine coverage I have classified by sections of the A.A.A.S. the subject matter of 258 principal articles which appeared in volumes 58 to 62 during my editorship. The results are expressed in percentages in Table 1. For comparison I list also in percent the distribution among sections of members who take the SM. The last column shows the difference between percentage of articles and percentage of members in the several sections.

Because many articles of opinion, which I call "wisdom," do not strictly apply to any particular section of the Association, I have classified them under Section K or L, because they have to do with scientists or the philosophy of science. The high percentage of contributions in these sections should therefore be discounted. Many other articles overlap two or more sections. These have been assigned to the section that seemed predominant. Because of these uncertainties another person might have arrived at a somewhat different set of figures. It is probable, however, that anyone would be struck by the relatively small percentage of articles in physics and chemistry, particularly the latter. No doubt contributions in these fields are infrequent because it is difficult to write informatively about highly technical subjects. Chemists, who are the most numerous readers of the SM, should recognize this deficiency and try to overcome it. Deficiencies more difficult to explain are also present in psychology, engineering, and medicine. In these subjects it should be possible to obtain large numbers of sound popular articles. In geography and zoology an excess is apparent.

TABLE 1

Percentage Distribution of SM Articles and Members by A.A.A.S. Sections

	Section	*Articles*	*Members*	*Difference*
A.	Mathematics	2.7	4.4	− 1.7
B.	Physics	4.6	8.7	− 4.1
C.	Chemistry	3.9	18.0	−14.1
D.	Astronomy	2.3	1.7	+ .6
E.	Geology and Geography	12.4	5.9	+ 6.5
F.	Zoological Sciences	13.6	8.4	+ 5.2
G.	Botanical Sciences	5.8	5.0	+ .8
H.	Anthropology	2.7	1.9	+ .8
I.	Psychology	3.5	6.2	− 2.7
K.	Social and Economic Sciences	13.6	3.5	+10.1
L.	Historical and Philological Sciences	12.0	1.8	+10.2
M.	Engineering	3.9	10.6	− 6.7
N.	Medical Sciences	7.4	17.0	− 9.6
O.	Agriculture	7.0	3.4	+ 3.6
Q.	Education	4.6	3.5	+ 1.1

Other subjects seem to be properly represented in proportion to membership by sections.

It may be instructive to classify our principal articles in other ways. For example, I find that 5 percent of the 258 articles are primarily biographical; 12.4 percent are chiefly historical; 29.8 percent are essays of "wisdom"; and the remainder, 52.8 percent, are primarily factual, having been written for the purpose of describing and explaining the present status of various scientific subjects. Whether this is a satisfactory distribution can be determined only by the readers.

Articles on the physical sciences, including geology, constitute 23.6 percent of the total; those on the biological sciences, including medicine, 33.7 percent; and the remainder, including the "wisdom," (42.7 percent) may be assigned to the social sciences. This simple classification points again to the deficiency of articles in physics, chemistry, and engineering.

The foregoing classifications give no information about the quality of articles published in the past five volumes. Like the contents of any other magazine, those of the SM can be improved. This can be most readily accomplished by accelerating the influx of new manuscripts, thus giving the editor a larger number from which to select the best. Perhaps potential contributors should be reminded that they need not wait for a personal invitation from the editor to write for the SM. Unsolicited manuscripts are just as welcome and are given just as careful attention as those that are solicited.

The quality of the contents of the SM can also be improved by increasing the membership of the Association. With greater resources behind the SM, the personnel of the editorial office might be increased, and authors might be paid for their efforts in cash as well as in reprints. With more help the editor could spend more time in soliciting and evaluating manuscripts, more effort could be devoted to revising and checking the contents of manuscripts, and color printing might become standard practice. If every reader of the SM would undertake to secure a new member for the Association, some of our dreams for a better SM might come true.

The third column in Table 1 should be examined by those who are planning to write for the SM or who may be desirous of placing an unpublished address. Note that more than half of the readers of the SM are physicists, chemists, engineers, and physicians, and that no field of science is unrepresented among the readership. Therefore, every article published in the SM should be interesting and intelligible to people of diverse training and experience. Recently we received the manuscript of an excellent address to a botanical audience. The author wanted it to appear in the SM in order to reach a large number of botanists. If he had known that 95 percent of the readers of the SM are not botanists, he would have sought publication in a botanical journal.

Old Hi Ho and young Ho Hum intend to debate the question whether articles for the SM should be written to please the readers or to please the authors. The editor will not be influenced by their harangue, however persuasive. With him readers come first, authors second.

F. L. Campbell